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Thermal Capsulorrhaphy of the Shoulder: Literature Review and Clinical Outcome for One Collegiate Tennis Player

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THERMAL CAPSULORRHAPHY OF THE SHOULDER: LITERATURE REVIEW
AND CLINICAL OUTCOME FOR ONE COLLEGIATE TENNIS PLAYER

By

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Bachelor of Science in Biology
University of Wyoming, 1997
Bachelor of Science in Physical Therapy
University of North Dakota, 2000

An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

in partial fulfillment of the requirements

for the degree of

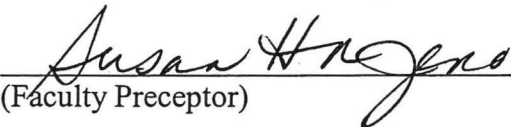
Master of Physical Therapy

Grand Forks, North Dakota

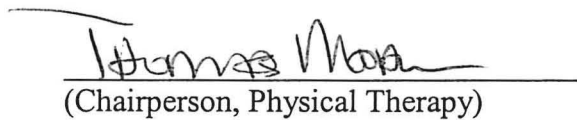
May
2001



This Independent Study, submitted by Kelsey Kean in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work had been done and is hereby approved.


(Faculty Preceptor)


(Graduate School Advisor)


(Chairperson, Physical Therapy)

PERMISSION

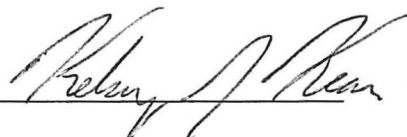
Title Thermal Capsulorrhaphy of the Shoulder: Literature Review and
Clinical Outcome For One Collegiate Tennis Player

Department Physical Therapy

Degree Master of Physical Therapy

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ABSTRACT

Glenohumeral joint instability is a clinical problem in both the athletic and general populations. When 3 months of conservative physical therapy treatments fail to stabilize the lax shoulder joint, surgery is indicated. Recently thermal capsulorrhaphy, an arthroscopic procedure that uses a heat probe to shrink redundant capsular tissue, has been offered as one alternative to tighten the lax glenohumeral joint capsule. There are numerous published reports describing the effects of thermal energy on joint capsular tissue, but only a few clinical outcome studies have been published regarding thermal capsulorrhaphy of the shoulder. Some initial reports of this surgical technique seem to be favorable for reducing shoulder instability in the overhead athlete and general population, but no long-term studies have been done to determine the efficacy of this surgical intervention. The purpose of this independent study was to review recent literature regarding thermal capsulorrhaphy, compare existing protocols, and to present an 18 month post operative clinical outcome of one collegiate tennis athlete who underwent the thermal capsulorrhaphy procedure to his serving shoulder.

The findings of this study indicate that no one protocol has been established for this patient population. The clinical outcome for the subject in this study was less than favorable as he was not able to return to playing collegiate tennis. Several of the contributing factors to this poor clinical outcome were identified, which included: too

short of immobilization period following thermal capsulorrhaphy, no physical therapy interventions for 6 weeks postoperatively, and the performance of resisted shoulder extension exercises at six weeks postoperatively.

A physical therapist's understanding of collagen maturation process is imperative in designing a rehabilitation program for patients who have undergone thermal capsulorrhaphy of the shoulder because the ultimate tensile strength of the shrunk capsule is unknown at this time. Early physical therapy intervention and careful monitoring of patient range of motion to prevent re-stretching of the glenohumeral capsule are also crucial to a successful clinical outcome. Only more long-term clinical outcomes will determine if this will become the gold standard for treating shoulder instability.

CHAPTER I

INTRODUCTION

The most unstable joint in the body is the shoulder.¹ Multidirectional instability (MDI) of the shoulder is seen as a clinical problem in both the athletic and general populations.² Commonly, the athlete that participates in sports that require repetitive overhead activity develop shoulder instability.³ The instability is the result of injury caused by microtrauma (plastic deformation and microtears) to the shoulder capsule.² Less often MDI is the result of a traumatic injury that is associated with gross capsular tearing. Redundancy of the inferior glenohumeral ligament complex (IGHLC), which leads to an increase in capsular volume, is believed to be the underlying cause of MDI.^{2,3} The instability becomes worse with time and activity, with the initial secondary changes believed to be occurring early in the rotator interval, which refers to a general area of the anterior capsule.^{2,3} The rotator interval is further defined as the space between the superior border of the subscapularis and the superior border of the supraspinatus muscles along with the region of the capsule that contains the superior glenohumeral ligament (SGHL), the middle glenohumeral ligament(MGHL), and the coracohumeral ligament.⁴ It is felt that the secondary changes associated with MDI occur at a later time to the labrum and more superior aspects of the shoulder capsule than the secondary changes that occur in the rotator interval.^{2,3}

Rehabilitation of the shoulder is multifaceted process that must address both static and dynamic stabilizing structures of the glenohumeral (GH) joint.³ Conservative physical therapy for the treatment of capsular laxity is often initiated by employing scapular stabilizing exercises and rotator cuff muscle strengthening.^{2,3} Strengthening of the larger muscles of the shoulder such as the deltoid, pectoralis major, and latissimus dorsi are not performed until normal scapular and rotator cuff function is achieved by the patient. Satisfactory results of 90% or more can be expected within 6 months of implementing this nonoperative treatment if the physician, therapist, and athlete are patient and work together.² If however, the symptoms of pain and functional stability continue to be problematic, surgical alternatives should be considered to restore stability to the shoulder.

Several surgical interventions exist for the treatment of MDI of the shoulder. Open and arthroscopic surgical techniques have been used to repair instability of the GH ligaments and capsule. Since 1980, open capsular shift procedures have proven to be successful and with few complications in restoring stability to the GH joint.^{2,3} However, recovery of full functional range of motion (ROM), especially for the overhead athlete,⁵ was often not obtained postoperatively with the open surgical technique due to the degree of tissue death and necessary postoperative immobilization.³ An alternative to the open surgical techniques was developed through the advent of arthroscopic procedures for the treatment of GH joint instability. The arthroscopic procedures are seen as advantageous, because of decreased surgical morbidity, shorter hospital stay, less pain postoperatively, improved cosmesis, and shoulder ROM is not compromised, therefore leading to a more rapid recovery.^{2,6} However, arthroscopic surgical procedures to stabilize the GH joint

instability have higher failure rates than open surgical techniques and require extreme technical expertise.⁵ The need is apparent for a simpler surgical procedure that eliminates shoulder instability, while permitting the patient to return to their previous level of activity or competition.

Recently, an arthroscopic procedure that utilizes a heat source to shrink redundant capsular tissue has been offered as an alternative technique to the open and to the previously mentioned arthroscopic procedures to tighten the lax shoulder capsule. This arthroscopic surgical technique is referred to as thermal capsulorrhaphy or thermal shrinkage of the shoulder. Currently, both laser and radio-frequency probes are being used by surgeons to heat capsular tissue in the shoulder.⁷ However, more recently the use of temperature specific radio-frequency thermal probe devices, which provide more precise and controlled rate of shrinkage have surpassed the holmium: yttrium, aluminum garnet (Ho: YAG) laser for tightening the lax shoulder capsule,^{2,7} as will be discussed in more detail in chapter 5.

A decrease in capsular redundancy has been reported to occur due to the effect of laser and radio frequency thermal energy on animal and cadaver joint capsular tissue. Decreased GH tissue length and volume have been shown in cadaveric inferior GH ligaments as well as increased average tensile force after exposure to thermal energy.^{2,8} Lopez, Hayashi, and Fanton⁹ have found a strong correlation between treatment temperature and percent of affected tissue area. The thermal effect of laser energy was in its ability to alter collagen fibril architecture, which resulted in the capsular shrinkage. Collagen fibril cross-sectional area has been shown to increase when compared to control specimens following laser application^{2,9} and fibril size variation has been found to

decrease with increasing exposure temperature.⁹ It is for these reasons that orthopedic surgeons have begun to use this technology in the treatment of shoulder instability.

With numerous published reports describing the effects of thermal energy on joint capsular tissue, only a few clinical outcome studies have been published regarding thermal capsulorrhaphy of the shoulder. Some initial reports of this surgical technique seem to be favorable for reducing shoulder instability in the overhead athlete, but no long-term studies have been done to determine the efficacy of this surgical intervention.^{2,3,7} The purpose of this independent study was three fold. The first purpose was to review the literature regarding the most recent developments of thermal capsulorrhaphy procedure. The second purpose was to compare and contrast different post surgical rehabilitation protocols that have been attempted with this patient population and to determine which rehabilitation protocols are most successful. The third purpose was to examine the clinical functional outcome for one collegiate tennis athlete, who underwent thermal capsulorrhaphy procedure to his serving shoulder and the subsequent period of extensive physical therapy rehabilitation. This study begins with a basic gross and microscopic anatomical review of the shoulder joint and capsular tissues.

CHAPTER II

ANATOMY/BIOMECHANICS

Although the upper limbs of the human body make up less than 10% of the total weight of the human body, this small piece of body mass contains the hand, which is one of the main features that separates humans from other animals.¹⁰ The function of the hand is dependent on shoulder mobility. The shoulder joint exhibits the greatest mobility of any joint in the body, and thus it is an inherently unstable joint.^{11,12} Anatomic factors that help stabilize the shoulder joint are its geometry, ligaments, and dynamic stabilizers. When one or more of these structures fails, shoulder instability may arise.¹¹ Failure of one or more of these structures is quite possible in the shoulder of the overhead athlete.

The shoulder can be divided into five component parts: glenohumeral joint (GH), acromioclavicular joint, sternoclavicular joint, scapulothoracic joint, and suprahumeral joint. In order for normal motion of the shoulder to occur all five components must be working properly. However, for the purposes of this paper, only the anatomy and biomechanics of the GH joint will be discussed because it is the GH structures that are specifically involved in the thermal capsulorrhaphy surgical procedure and the subsequent rehabilitation process that is the focus of this review.

Joint Geometry

The GH joint is a ball and socket synovial joint with three degrees of freedom.¹⁰ It is formed by the articulation between the large head of the humerus and the glenoid

fossa of the scapula. There is some discrepancy among authors regarding the orientation of the glenoid fossa. A majority of authors have reported that the glenoid fossa faces superiorly, anteriorly, and laterally,¹⁰⁻¹² while Norkin and Lavangie¹⁰ report there are variations in glenoid fossa orientation with a slightly inferiorly instead of superiorly oriented glenoid fossa being the most common orientation variation. The humeral head faces medially, posteriorly and superiorly in regard to the shaft of the humerus.^{10,11} The angle of inclination of the humerus is described as the axis through the humeral head and the longitudinal axis of the shaft of the humerus, which normally forms a 130-150° angle. Enhancing the articulation between the head of the humerus and the glenoid fossa is the glenoid labrum.

Glenoid Labrum

An accessory structure known as the glenoid labrum enhances the total available articular surface of the glenoid fossa.^{10,12} This structure is a redundant fold of dense fibrous connective tissue attached to the periphery of the glenoid fossa by fibrocartilage. The shape of the glenoid labrum resembles a triangular shape in cross-section (Figure 1) and may resemble the meniscus in the knee with a free inner edge that projects into the joint space.⁴ This connective tissue fold is continuous with the joint capsule superficially.¹⁰ There is some debate regarding the role of the labrum as a stabilizing structure.¹² The labrum deepens the glenoid fossa from approximately 2.5 mm to 5 mm. One way that the glenoid labrum may aid stabilization of the shoulder is in combination with joint compression forces in midrange shoulder motions, where ligamentous capsular structures are lax. Resection of the labrum in biomechanical studies have shown that it can reduce the effectiveness of compression stabilization by 20%. The labrum also

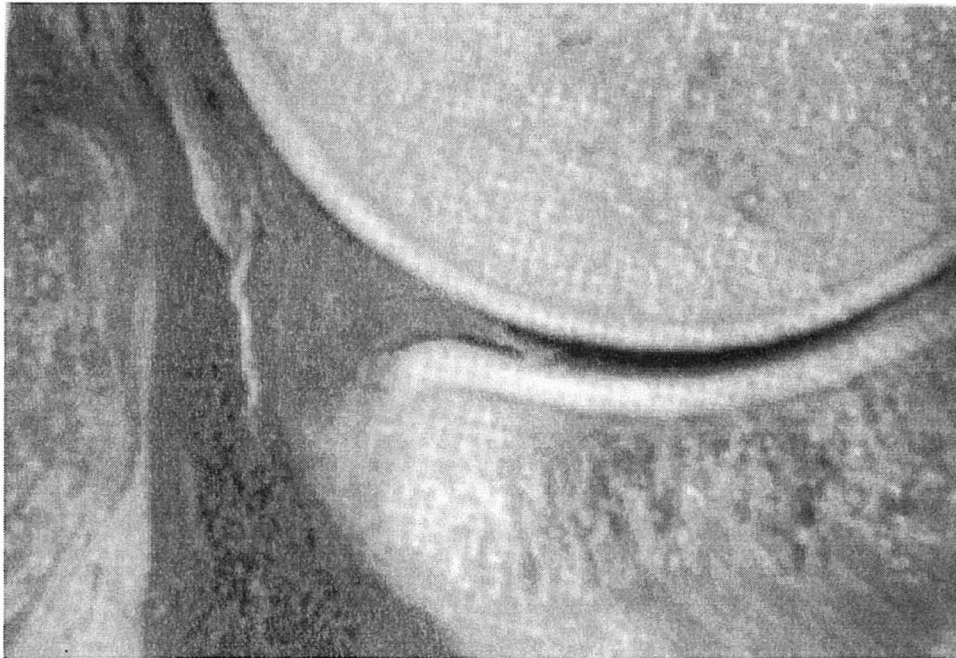


Figure 1. The glenoid labrum, the rim of fibrous tissue that is triangular in cross-section, overlies the glenoid cavity at the rim or edge. It may have a striking resemblance to the meniscus in the knee. (Reprinted with permission from: Rockwood CA Jr, Matsen FA III, eds. *The Shoulder*. Vol 1. 2nd ed. Philadelphia, Pa: W.B. Saunders Co; 1998.)

assists in controlling GH translation by its triangular shape, which acts like a buttress in much the same manner as a chock-block placed behind a tire of a vehicle.^{4,12}

Glenohumeral Capsule and Ligaments

The structures that make up the GH capsule and ligaments provide a static check against excessive humeral translation at extreme positions.⁷ The GH capsule is 2 times the size of the humeral head.^{4,10} The large, lax capsule is necessary to allow large movement of the shoulder joint.¹⁰ However the capsule provides minimal stability without ligaments and muscles reinforcing the GH joint. When the humerus is abducted in the frontal plane, the capsule twists on itself and tightens somewhat. The twisting action is increased when the humerus is externally rotated while abducted, thus making abduction combined with external rotation the closed pack position for the GH joint.¹⁰ The closed pack position is characterized by the joint capsule and ligaments being maximally tensed while the articulating joint surfaces demonstrate their maximal congruency.¹³ The closed pack position for the shoulder is a position that the overhead athlete must frequently assume during performance of their sporting activity.

There are 3 GH ligaments that form distinct thickenings in the capsule and provide reinforcement to the GH joint^{7,10} as can be seen in Figure 2. The superior, middle, and inferior GH ligaments form a "z" on the internal surface of the anterior capsule. These ligaments show great variation in size, shape, thickness, and attachment site.⁴ The function of these ligaments is dependent on their collagenous integrity, their attachment sites, and the position of the arm.

The superior glenohumeral ligament (SGHL) originates from the anterosuperior labrum just anterior to the long head of the biceps origin and inserts superior to the lesser

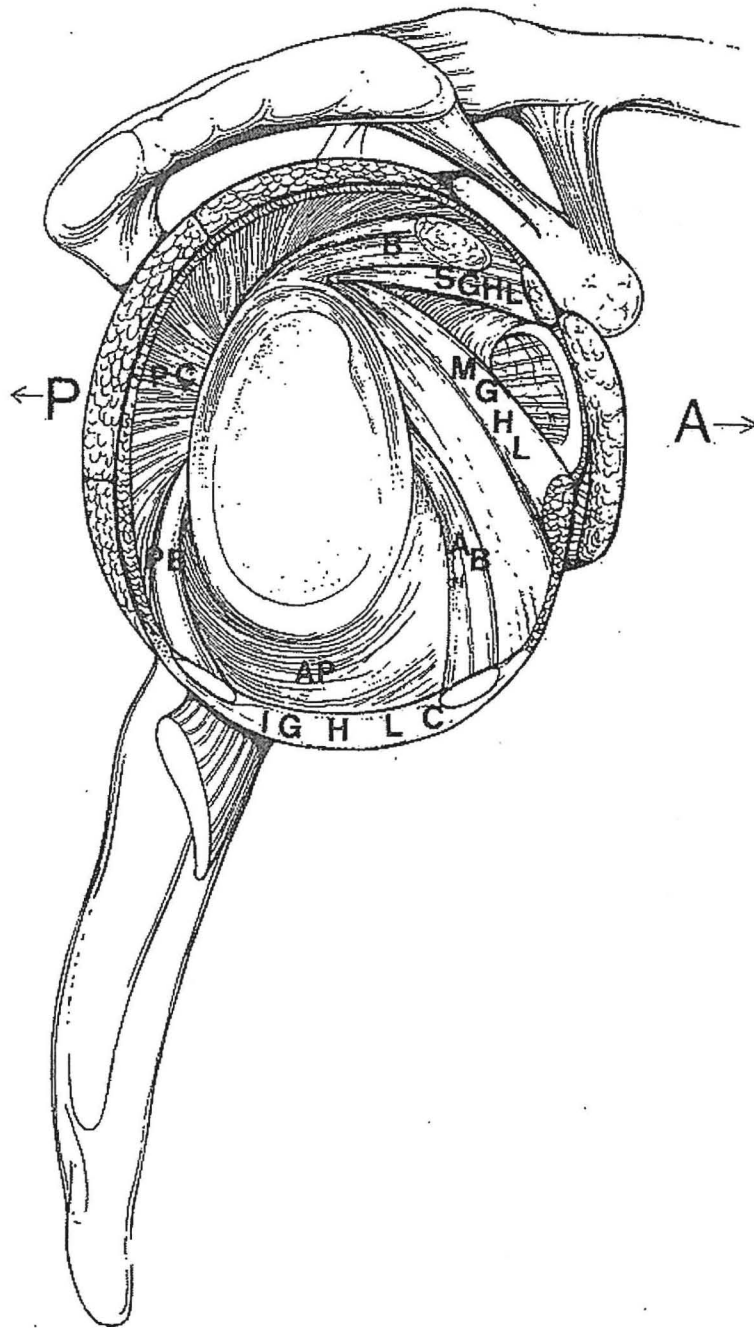


Figure 2. Anatomic depiction of the glenohumeral ligaments and inferior glenohumeral ligament complex (IGHLC). P, Posterior; A, anterior; SGHL, superior glenohumeral ligament; MGHL, middle glenohumeral ligament; B, long head of the biceps tendon; PC, posterior capsule; PB, posterior band; AB, anterior band; AP, axillary pouch. (Reprinted with permission from: Rockwood CA Jr, Matsen FA III, eds. *The Shoulder*. Vol 1. 2nd ed. Philadelphia, Pa: W.B. Saunders Co; 1998.)

tuberosity of the humerus.^{4,12} However, there are three common variations that can be seen in the glenoid attachment site of the SGHL, which are illustrated in Figure 3.⁴ The SGHL can originate from a common origin with the biceps tendon, arise from the labrum just anterior to the biceps tendon, or it may arise with the origin of the middle glenohumeral ligament (MGHL).

The MGHL originates from the labrum, just inferior or adjacent to the superior GH ligament.^{4,12} The middle GH ligament inserts laterally on the lesser tuberosity of the humerus under the subscapularis tendon. This ligament shows the greatest variation in size and is not present as often as the other two GH ligaments.⁴ Its contribution to static stability is variable, but when it is thick, it is reported to act as an important secondary restraint to anterior translation of the humeral head if damage occurs to the anterior band of the inferior glenohumeral ligament complex (IGHLC).

The IGHLC originates from the glenoid and inserts into the anatomic neck of the humerus.⁴ The IGHLC is made up of three distinct parts: an anterior band, a posterior band, and an axillary pouch that lies between the anterior and posterior bands (Figure 2).^{4,12} The shape of the entire IGHLC has been described as being triangular with the apex at the labrum and its base blending with the capsule between the subscapularis and triceps area.⁴ The anterior superior edge of the anterior band is especially thick. The IGHLC is considered the main static stabilizer of the abducted shoulder. With shoulder abduction and external rotation, the anterior band of the IGHLC fans out and functions to restrain anterior displacement of the humeral head, while the posterior band prevents inferior displacement of the humeral head.^{4,12} When the shoulder is internally rotated and abducted, the IGHLC moves inferiorly to resist inferior translation as the posterior band

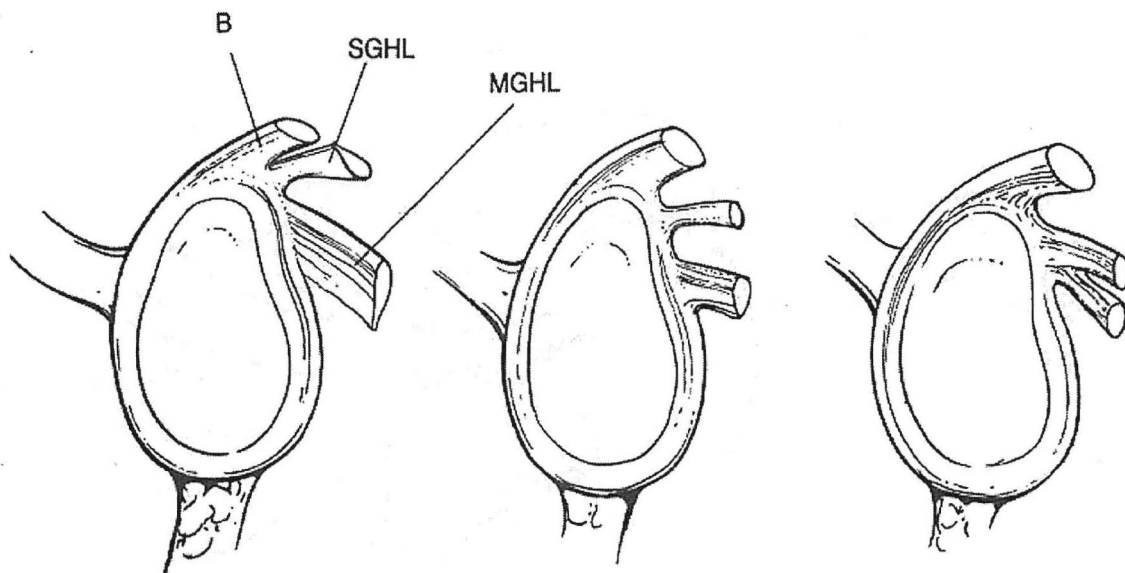


Figure 3. Three common variations of the origin of the superior glenohumeral ligament (SGHL) B, biceps tendon; MGHL, middle glenohumeral ligament. (Reprinted with permission from: Rockwood CA Jr, Matsen FA III, eds. *The Shoulder*. Vol 1. 2nd ed. Philadelphia, Pa: W.B. Saunders Co; 1998.)

shifts in a posterior and superior direction to prevent posterior translation. When the shoulder is abducted 90° and placed in 30° of extension the anterior band of the IGHLC serves as the primary stabilizer against both anterior and posterior translation.¹² In general, the superior capsular structures play a significant role in GH stability when the shoulder is adducted, while the inferior capsular structures are the ultimate joint stabilizers from 90° of abduction toward full elevation.

A fourth ligament, the coracohumeral ligament, originates from the coracoid process of the scapula and blends into the superior portion of the capsule along with the supraspinatus tendon to insert on the greater tubercle of the humerus.^{7,10} This ligament functions to give passive support of the upper extremity against the force of gravity and aids in checking external rotation of the humerus.

Intra-articular Pressure and Joint Cohesion

Stability is enhanced in the normal GH joint by the sealed airtight capsule.¹² The GH capsule normally contains less than 1 ml of fluid, however it is this small amount of fluid that assists in providing joint stability through viscous and intermolecular forces holding articulating joint surfaces together, in much the same manner as what occurs with syringe type suction. The stabilizing pressure is thought to be rather small at approximately 20-30 pounds of pressure. However, if the capsule is punctured or a labral tear occurs, it results in atmosphere pressure changes within the capsule and a loss of passive GH joint stability has been noted and subluxation tends to occur anteriorly, posteriorly, and most significantly inferiorly. Furthermore, following arthrotomy of the GH joint a resumption of stabilizing intra-articular pressure has not been seen in studies done on the joint.

Dynamic Stabilizers of the Glenohumeral Joint

The dynamic stabilizers of the GH joint are primarily made up of four muscles: the supraspinatus, infraspinatus, teres minor, and subscapularis, commonly referred to as the rotator cuff.^{11,12} These muscles along with the deltoid and long head of the biceps brachii provide the majority of the dynamic stability for the GH joint.¹² The tendons of the rotator cuff muscles blend with the articular capsule of the shoulder joint.^{11,12} The rotator cuff provides protection and gives stability to the shoulder by holding the head of the humerus in the glenoid cavity during active arm movements. Contraction of the deltoid muscle causes the humeral head to translate superiorly in the glenoid cavity, a direction parallel to the GH joint, thus it is not a stabilizing influence by itself.¹⁰ The superior translatory force exerted by the deltoid is offset by the rotator cuff's inferior translatory pull and together these opposing muscle groups add to the dynamic stability of the GH joint.^{10,12} The long head of the biceps tendon enters the joint capsule in an opening between the supraspinatus and subscapularis muscle tendons.¹⁰ It is here that the tendon penetrates the capsule, but not the synovium. Due to its location in relation to the GH capsule it is believed to provide some reinforcement to the GH joint.

Secondary dynamic stabilizers of the GH joint include the teres major, latissimus dorsi, and pectoralis major muscles.¹² These muscles insert on the upper humerus and function to enhance stability of the humeral head during active arm movements. Both primary and secondary dynamic stabilizers act together in an agonist/antagonist relationship to provide movement of the arm in addition to their stabilizing function of the GH joint.

Dynamic Stability Through Neuromuscular Control

Another component contributing to dynamic stability of the shoulder is what is termed neuromuscular control.¹² The continuous interplay of afferent input from joint mechanoreceptors to the central nervous system (CNS), and efferent output from the CNS back to the joint structures helps provide an individual with proprioception, which is the awareness of a joint's position in space. Appropriate proprioception along with voluntary muscular contraction help stabilize the GH joint or alter the joint's position in order to prevent excessive humeral head displacement. Recently the presence of Ruffinian and Pacinian corpuscles and Golgi mechanoreceptors have been noted within the capsulolabral structures, especially in the inferior aspect of the GH joint capsule. It is felt that these stretch sensitive mechanoreceptors within the capsular ligaments are activated by tension, from either an active muscle contraction or a passive movement force, that then elicits a muscular contraction to protect the GH ligaments at the extremes of shoulder motion. As will be discussed in chapter 5, it is precisely the IGHLC where the thermal capsular shrinkage procedure begins, thus raising concerns regarding proprioception abilities of the shoulder after surgery.

An understanding of the collagen fibril architecture that composes capsular tissue is necessary in order to understand the basic science of how thermal energy has the ability to alter and shrink redundant capsular tissue. Of greater importance to the physical therapist, is how the collagen fibril architecture is changed and repairs itself during the rehabilitation process after thermal shrinkage. The microanatomy of the collagenous GH joint capsule is discussed further in chapter 3.

CHAPTER III

MICROANATOMY

OF THE COLLAGENOUS GLENOHUMERAL JOINT CAPSULE

The most plentiful protein in mammals and the major component of connective tissue is collagen.¹⁴ Collagen's mechanical and tensile properties provide connective tissue with a unique combination of flexibility and strength.¹⁵ On the microscopic level, one distinguishing feature of a collagen protein molecule is its long rigid triple-helical structure: three collagen polypeptide chains, called α -chains, that form a rod like molecule (Figure 4).¹⁴ There are approximately 25 separate collagen α -chains that have been identified, and to date 15 types of collagen molecules have been found.

Several different collagens can be localized in connective tissue structures. However, type I collagen is the most abundant type found in connective tissues,¹⁴ and is the dominate construct of ligaments and tendons.^{15,16} Type I collagen is held in its triple helical confirmation by heat sensitive hydrogen bonds. When these heat sensitive bonds are broken, the helical structure begins to disassociate and the molecule physically contracts (Figure 5).¹⁵ The process of disruption of the native conformation of a protein by environmental changes or chemical treatments with concomitant loss of biological activity is defined as denaturation.¹⁶ Denaturation of collagen occurs during thermal heating as a result of the unwinding of the triple-helix molecule into a more random coil (Figure 5).¹⁷ However, the individual collagen fibrils that form the triple helix are

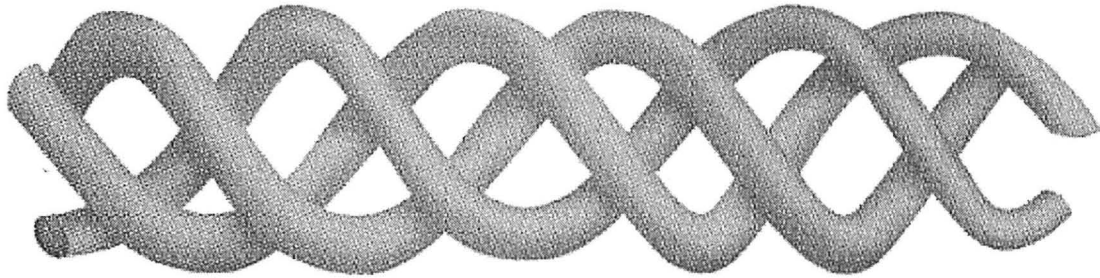


Figure 4. Type I Collagen Molecule Model Pre-thermal treatment (Reprinted with permission from: *Temperature Matters*. Oratec® Interventions, Inc. [package insert], 3700 Haven Court, Menlo Park, CA 94025; Phone 888-996-1996, or 650-369-9904; www.oratec.com.)

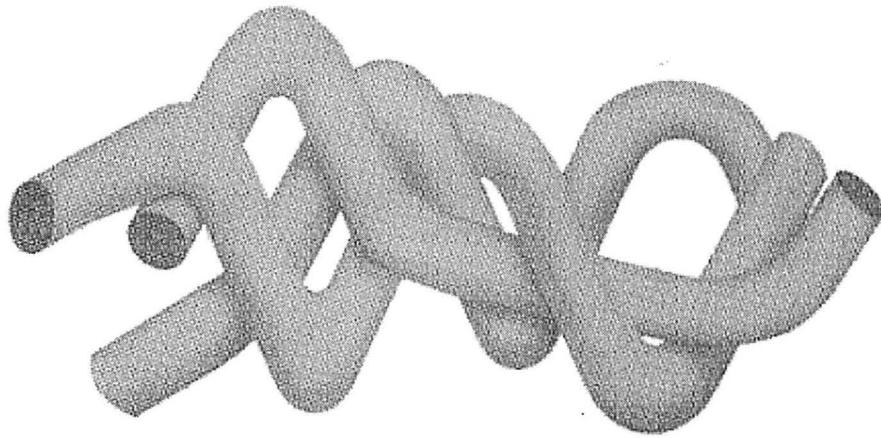


Figure 5. Type I Collagen Molecule Model Post-thermal treatment. (Reprinted with permission from: *Temperature Matters*. Oratec® Interventions, Inc. [package insert], 3700 Haven Court, Menlo Park, CA 94025; Phone 888-996-1996, or 650-369-9904; www.oratec.com.)

bonded by heat-stable intermolecular crosslinks, and thus the fibrillar structure of the collagen is not affected by thermal energy application.

Numerous studies have been done on the effects of heat on collagen. These studies have been performed on joint capsular collagen of rabbits,^{18,19} bovine,²⁰ sheep,²¹ and fresh-frozen cadaveric shoulders.⁸ Hayashi et al.⁸ studied 7 GH joint specimens from different GH joint regions from a total of 6 cadavers. The investigators assigned each specimen to 1 of 7 treatment groups (37°, 55°, 60°, 65°, 70°, 75°, and 80°C) using a randomized block design. Specimens were subjected to a 10-minute tissue bath at one of the determined temperatures. This study found that the specimens treated with temperatures at or above 65°C showed significant shrinkage compared with those treated with a 37°C bath. Significant thermal alteration was determined by histological analysis. Naseef et al.²⁰ demonstrated that thermal shrinkage of bovine knee capsule correlates with denaturation of collagen fibers and depends on both time and temperature. The investigators also observed the threshold for shrinkage in capsular tissue heated to be between 60° to 62° and maximal shrinkage of approximately 50% of the original length was achieved with exposures of 1 minute or greater. It also should be noted, that individual collagen fibrils contract in length while expanding in diameter during thermal treatment.¹⁹

Not only does time and temperature have an effect on the amount of collagen shrinkage, but they also have an effect on the biomechanical properties of collagen matrix. Increasing temperature dramatically effects the collagen's natural geometric structure when examined under electron microscopy and a complete melting or fusion of the collagen matrix can occur at temperatures above 65°C.^{15,20} This is important because

if a significant part of the collagen matrix is obliterated at a high temperature, the treated tissue can no longer act as a scaffold for migrating fibroblast during the body's natural healing process.¹⁵ Destruction of the collagen matrix results in increased changes in the biomechanics of the tissue such as normal stiffness and tensile strength of the collagen. Wall et al.²² measured that mechanical properties changed as a function of tissue shrinkage. The investigators of this study did this by uniaxial tensile testing of normal and heat-shrunken bovine tendon, and then developed a model to express the relationship between shrinkage and mechanical properties. The results of this investigation found that the mechanical properties decreased with increasing shrinkage, and that the maximal allowable shrinkage before significant material property changes occurred was between 15% and 20%. Further ultra-structural analysis completed with transmission electron microscopy also showed denaturation of the collagen fibrillar structure and provided direct support for the observed material changes.

Investigation of the mechanical properties of post-treatment tissues are reported to be underway, with preliminary data indicating an early decrease of tensile strength with a return to normal levels within 6 to 12 weeks.¹⁷ Obviously more research is warranted to determine the short and the long term effects on biomechanical properties of collagen repair following thermally treated capsules. Thermal capsulorrhaphy is currently being done to reduce GH instability, thus rehabilitation guidelines for this procedure must be based on the current scientific understanding of collagen denaturation and repair process.

CHAPTER IV

ETIOLOGY OF ATRAUMATIC SHOULDER INSTABILITY, CONSERVATIVE TREATMENT, AND INDICATIONS FOR SURGICAL STABILIZATION

Etiology of Atraumatic Shoulder Instability

Instability of the shoulder is a common problem, especially in the young active population.¹⁷ Athletes who use overhead movement patterns as an essential element in their sport are at risk for developing GH joint instability.³ An injury surveillance study of 1,440 tennis athletes 18 years of age and under was conducted over a 6 year period at the United States Tennis Association (USTA) Boy's National Championships.²³ The results showed the shoulder to be the 3rd most commonly injured area of the body for this age population making up 11.8% of all injuries reported during the tournament. However, no athlete was reported to have the complete syndrome of tennis shoulder at the USTA Boy's Championships. Tennis shoulder refers to a drooped, internally rotated shoulder that is caused by long-term overhead arm use and contributes to generalized laxity of the shoulder capsule and musculature. It has been documented that 50% of all athletes diagnosed with tennis shoulder will experience shoulder pain at some point during their playing career when the athlete attempts overhead strokes such as in the tennis serve. In this study, the prevalence of shoulder pain was found in 2.5 out of every 100 athletes. It was felt that the athlete's shoulder pain might be one indicator of developing tennis shoulder in these young competitive athletes.

Shoulder instability is not limited to just the young competitive athlete. There is a wide spectrum of people with shoulder instability ranging from people who experience atraumatic chronic dislocations due to microtears and plastic deformation of the capsule, to those who develop instability as a result of a single traumatic event, associated with a gross capsular tear.² However, the most common etiology of shoulder instability is a result of atraumatic repetitive microtrauma to capsular structures. It is believed that redundancy of the IGHLC with a resultant increase in capsular volume is the underlying pathoanatomy leading to atraumatic MDI of the shoulder. Secondary changes involving the rotator interval occur early, followed later by changes in the labrum and more superior parts of the capsule because the instability worsens with time and activity. As a result, recognition of various patterns of instability and types of impingement can be complicated, which in turn makes management and clinical outcomes for these patients quite variable, and leads to inconsistencies in the literature regarding functional outcomes.¹⁷

A common secondary complication of shoulder instability is shoulder impingement.² Shoulder impingement is anterior shoulder pain due to encroachment of capsular tissue or rotator cuff tendon(s) on a more rigid surface such as bone.⁴ In classifying shoulder impingement, and GH joint instability, the first divisor tends to be age.²⁴ People older than 35 tend to experience a classic type of impingement that results from compression of tissues (i.e. supraspinatus tendon) that are located outside the capsule against structures which include the anteroinferior acromion, the coracoacromial ligament, and the acromioclavicular joint. With the classic type of impingement, no shoulder instability is present. The younger population (<35 years) tends to experience

internal impingement, which occurs when redundant GH capsular tissue is compressed by the humeral head near the glenoid rim with movement of the unstable shoulder. Shoulder instability with internal impingement can arise in the young athlete because of repetitive microtrauma^{2,24} or from general hyperlaxity of an individual.²⁴ It is the pain associated with internal impingement that the overhead athlete commonly seeks medical attention for, and not complaints of shoulder instability. Interestingly, GH instability due to traumatic event, such as a fall onto an outstretched arm, does not result in any impingement. The focus of the remainder of this chapter will be on the etiology and treatment of shoulder instability commonly incurred by the overhead athlete.

Several painful shoulder conditions can arise as a result of instability in the overhead athlete.¹⁷ While performing throwing motions, the shoulder is subjected to very high loads, that place repetitive strain on the capsule and labrum.^{17,24} Athletes often have labral tears without the sensation of subluxation or looseness.¹⁷ Additionally the athlete's rotator cuff muscles are exposed to high eccentric loads, specifically during the deceleration phase of the throwing motion. If the rotator cuff becomes fatigued or is weakened as a result of injury, increased stress is placed on the GH joint capsule, ligaments, and labrum. Oppositely, as the anterior static restraints become lax from repetitive stretching, more strain is placed on the rotator cuff. Thus, the overhead athlete is prone to the development of rotator cuff injuries and internal impingement. In an athlete with anterior capsuloligamentous laxity, the humeral head does not translate posteriorly when abducted and externally rotated, as would be expected in a joint without increased laxity. In fact, anterior translation of the humeral head may occur, further stretching the GH ligaments.

Excessive loads can be placed on the postero-superior labrum, capsule, and rotator cuff as they become caught between the hyperabducted, externally rotated humerus and superior glenoid.¹⁷ In addition, antero-inferior labral detachment is often associated with some degree of capsular disruption from the glenoid neck due to excessive translation of the humeral head with the periphery of the glenoid and capsulolabral structures.¹² This detachment creates laxity in an important GH stabilizer, the IGHLC.

The IGHLC has been identified as a major static restraint to anterior humeral head translation in the abducted shoulder.^{3,12} The IGHLC has been found to be subject to plastic deformation before tearing of the ligament actually occurs.⁷ The plastic deformation results in laxity of the shoulder capsule, and may lead to subluxation and secondary external impingement of the rotator cuff tendons between the humeral head and the acromion process of the scapula. As one can see, there are many causes for GH joint instability in an overhead athlete that may ultimately lead to a painful internal or external impingement of their shoulder and limit their ability to perform. This, in essence, is what makes treating shoulder instability for an athlete challenging.

Conservative Treatment for Recurrent Shoulder Instability

The key element to stabilizing the humeral head in the glenoid is strong, coordinated muscle contraction.⁴ This requires optimal neuromuscular control of the rotator cuff muscles, deltoid, pectoralis major, and scapular musculature. Therefore, nonoperative management for shoulder instability includes strengthening the muscles of the rotator cuff, deltoid, and scapular stabilizers.^{2,4,25} Early in the rehabilitation program, the patient is taught to use the shoulder only in the most stable positions, that is, those positions in which the humerus is elevated in the plane of the scapula.⁴ With improved

coordination and confidence, less stable positions are attempted and the patient is progressed to smooth repetitive activities, which train the neuromuscular patterns required for stability.

Shoulder strengthening initially begins using rubber tubing to strengthen the rotator cuff muscles and the deltoid.^{4,25} The program is based on the principle of progressive resistance. Rubber tubing is available that provides increasing resistance from 1 to 6 pounds.²⁵ Each exercise, as illustrated in Figure 6, is done 2 to 3 times a day, completing 5 repetitions each session, holding for a count of 5. Once a patient is proficient with the rubber tubing resistance exercises, the patient is given an exercise kit, that consists of a pulley, hook, rope and handle.^{4,25} The same core exercises are performed with the pulley exercise kit. Eight to 10 pounds of resistance is used to perform the exercises, and again the exercises are performed with the same frequency and duration as was done with the rubber tubing. The weight is gradually increased in 2 pound increments over several months, to as much as 25 pounds. The purpose of the 5 exercises is to strengthen the 3 parts of the deltoid muscle, the internal rotators, and the external rotators. The scapular stabilizers (serratus anterior and rhomboids) are strengthened by instructing the patient to perform wall push-ups, progressing to knee push-ups, and then finally progressing to regular push-ups. Shoulder shrug exercises are also performed to strengthen the trapezius and levator scapulae muscles. It is important that the patient understands that they should not progress too rapidly with any of the exercises, as this will lead to shoulder discomfort and will prevent proper strengthening of the muscles.²⁵ Lastly, it is important that the patient avoids all activities and habits

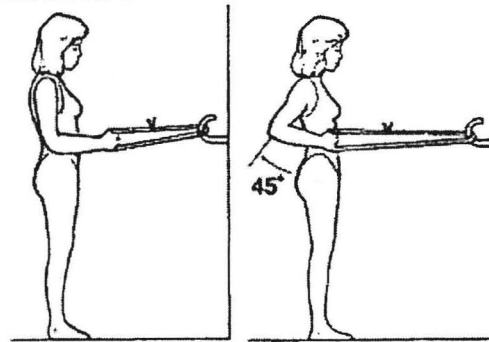
Shoulder Strengthening Exercises

Shoulder Service—Department of Orthopaedics
The University of Texas Health Science Center
at San Antonio

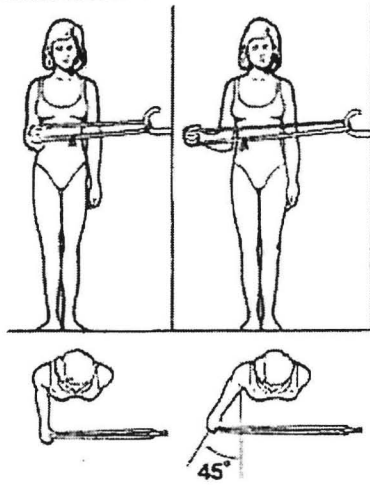
Do each exercise _____ times. Hold each
time for _____ counts. Do exercise program
_____ times per day.

Begin with Yellow Theraband for _____ weeks.
Then use Red Theraband for _____ weeks.
Then use Green Theraband for _____ weeks.
Then use Blue Theraband for _____ weeks.
Then use Black Theraband for _____ weeks.
Then use Gray Theraband for _____ weeks.

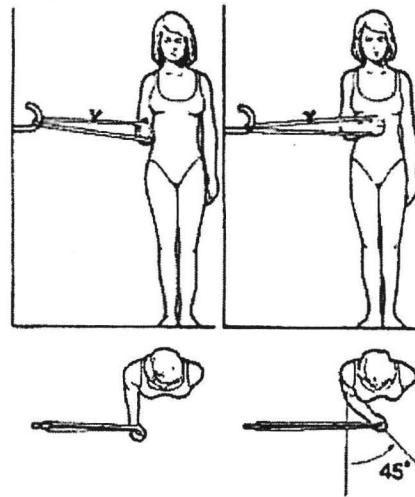
EXERCISE 3



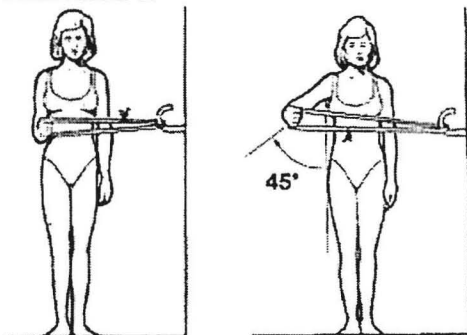
EXERCISE 1



EXERCISE 4



EXERCISE 2



EXERCISE 5

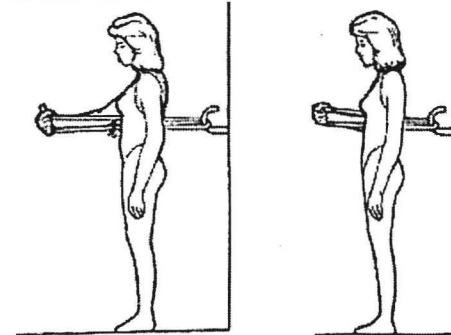


Figure 6. A specific rehabilitation program to strengthen the deltoid, rotator cuff, and scapular stabilizer muscles. (Reprinted with permission from: Burkhead WZ Jr, Rockwood CA Jr. Treatment of instability of the shoulder with an exercise program. *J Bone Joint Surg Am.* 1992;74:890-896.)

that promote glenohumeral subluxation or dislocation, and that the patient is taught that each time their shoulder "goes out" it gets easier for it to "go out" the next time.

Indications for Surgical Stabilization

In general, patients that have failed to improve within 6 months of initiating a conservative rehabilitation program are considered candidates for surgical stabilization of the GH joint.² The indications for thermal capsulorrhaphy surgical procedure are still evolving, but patient should meet the following criteria.⁷ The patient should have symptomatic shoulder instability that is adversely affecting the patient's quality of life or occupation for a duration of at least 6 months and have failed a minimum of 3 months of conservative treatment consisting of rest, modifications of activities, and rehabilitation. Thermal Capsulorrhaphy can be done alone for capsular laxity, or in conjunction with other arthroscopic structural repairs or partial rotator cuff debridement. Absolute contraindications to this procedure include patients with evidence of psychiatric, voluntary habitual dislocation, malingering, or chronic pain syndrome such as reflex sympathetic dystrophy. Several other contraindications to thermal capsulorrhaphy were presented at the International Society of Arthroscopy , Knee Surgery and Orthopaedic Sports Medicine conference on May 30, 1999.²⁶ The additional contraindications included large Hill-Sachs lesion, capsular rupture, contact athletes, revision surgery, and tissue that is unresponsive to thermal application. Upon radiographic evaluation of a patient, the ideal candidate would not reveal any of the following: a bony Bankart lesion, glenohumeral dysplasia, fractures, tumors, or infection.⁷ The patient should exhibit an intact and lax GH capsule or IGHLC with imaging. The physical examination should reveal a subluxating humeral head anterior, inferior, or posterior with provocative stress

tests. The ideal patient should have a positive apprehension test with a positive relocation test. At the time of the evaluation, the patient may have unidirectional or multidirectional instability.^{7,26} If the instability is greater than a grade 2 (0 being no humeral head translation within the glenoid fossa, and 3 being severe humeral head translation in which the humeral head rides up and over the glenoid rim⁴), then an inferior capsular shift is indicated for surgically stabilizing a GH joint.⁷ Also, patients with grade III sulcus (a measurement greater than 2 cm from the inferior margin of the acromion to the humeral head²⁷) on the inferior laxity testing are not considered good candidates for thermal capsulorrhaphy and are better treated by an open inferior capsular shift.⁷

Before thermal capsulorrhaphy surgery is performed, it is imperative that the patient understands that surgery is not a “cure” and that satisfactory outcome will only be achieved if the patient is compliant with a rehabilitation program. Thermal capsulorrhaphy is a relatively new procedure, and patient should be given preoperative instructions regarding expectations and what will be done intraoperatively.⁷ The patient should be made familiar with postoperative immobilization, cryotherapy, and exercises. Since this procedure is performed on an outpatient basis, the patient should have their postoperative analgesic prescription filled prior to the actual surgery. Tyler et al.⁷ has observed greater pain at rest in patients who have undergone thermal capsular shrinkage procedure as compared to those who have undergone open stabilization procedures. If the patient meets all the criteria discussed here, then they are ready to undergo the thermal capsulorrhaphy procedure to treat their shoulder instability.

CHAPTER V

SURGICAL TECHNIQUE

In the young or athletic client, recurring GH joint instability is common.⁸ Non-operative treatment has non-acceptable recurrence rate in the young athletic individual. Surgical treatment techniques for shoulder instability focus on reinforcing the GH joint capsule through open and arthroscopic techniques.⁷ The open surgical technique was first described in 1980 by Neer and Foster²⁸ and the principle of this open surgical technique was to symmetrically tighten the anterior, inferior, and posterior aspects of the capsule by advancing its humeral attachment.²⁴ The open surgical approach is commonly an anterior approach entering through the deltopectoral groove medial to the cephalic vein. The subscapularis tendon is then carefully dissected from the capsule. With the Matsen's²⁴ approach, the anterior capsule is cut from the humeral neck and traction sutures are placed on the incised margin. This differs from the Rockwood's²⁴ approach, which releases the anterior capsule half way between its attachment on the humerus and on the glenoid rim. Regardless of which technique is used, the quintessential element of the open surgical technique for reconstruction of atraumatic shoulder instability is the reduction of the posteroinferior recess by an anterosuperior advancement of the capsule combined with closure of the rotator interval capsule. This is accomplished by making release holes in the humeral neck, and passing tying sutures through these holes to tighten and reattach the capsule to the humeral neck. The subscapularis is then reattached to its

original insertion and the incision is closed. Due to the large number of tissues involved, the open surgical techniques result in high morbidity and require prolonged rehabilitation.^{7,8} In addition, few overhead athletes are able to return to their pre-injury activity level following the open surgical technique,⁸ and only 50% of elite throwing athletes return to their prior level of competition.²⁴

Arthroscopic repair for GH instability is thought to be advantageous over open repair. The arthroscopic repair using the Harryman's²⁴ surgical technique is as follows. Single anterior and posterior portals are necessary for scope and instrument access. The peripheral rim of the glenoid labrum is roughened with a motorized shaver. A suture hook is used to bring up approximately 1 cm of the inferior capsule in a posterosuperior direction to buttress the glenoid labrum. The posterior and anterior capsule is then shifted in a similar fashion about the labrum. Sutures are placed through the capsule and between the annular fibers of the glenoid labrum, adjacent to the articular cartilage. This helps increase glenoid depth and reduce the capsular redundancy. If further capsular tightening is needed, rotator interval plication (stitching folds in the capsular wall to reduce its size) is performed with a suture hook working within the subacromial space. The portals are then sutured closed. Arthroscopic surgery procedures have higher failure rates than open surgical techniques. They also require extreme technical expertise, and even can be contraindicated in the case of capsular redundancy-related shoulder instability. Thus, it is apparent that there is a need for a simpler surgical procedure that eliminates capsular redundancy, decreases joint volume, and helps stabilize the shoulder, while permitting the client to return to their previous level of competition or activity.

One new surgical technique that has been developed to address shoulder instability uses thermal energy to shrink the GH capsuloligamentous structures. This arthroscopic surgical procedure can be done alone for redundant capsular tissue, or may be done in combination with other structural repairs or partial rotator cuff debridement.⁷ At present there are two modalities at the surgeon's disposal that can be used to deliver the thermal energy needed to shrink the collagen in the capsuloligamentous structures, laser and radio-frequency.^{7,29} There are advantages and disadvantages for both the laser and radio-frequency approach. According to both Tyler et al.⁷ and Nottage,²⁹ the laser is more marketable and well known to the patient. One advantage of the radio-frequency thermal-delivery systems over the laser is that they are less expensive.⁷ A second advantage to the radio-frequency thermal-delivery system is that it only affects the tissue that it is actually touching, whereas the laser light has an affect on whatever tissue lies in its path, including healthy structures. Also, there is very poor control of tissue temperature with the laser and this is, in part, why radio-frequency devices are preferred by surgeons.^{2,7} Osteonecrosis has been reported to have occurred in the femoral condyle of the knee in several case studies as a result of the use of a laser.⁷ Risking osteonecrosis of the humeral head is not acceptable, especially when one considers the young age of the athletes who are the best candidates for the procedure. The disadvantages of the laser seem to outweigh its advantages, making it the least desirable thermal-delivery system.

Currently surgeons have the choice of using Ho: YAG laser or one of three manufactures that offer the radio-frequency thermal-energy systems, each with different delivery wand options such as depth of penetration and ability to control the probe temperature.⁷ Table 1 discusses the basic differences between mechanisms of energy

Table 1. The Basic Science of Laser and Radio-frequency Tissue Shrinkage*

| | Mechanism of Energy Transmission | Mechanism of Heating Target Tissue | Depth of Tissue Penetration |
|----------------------------------|--|--|--|
| Ho: YAG Laser | Intense beam of light (photons) 2.1 μm wavelength | Stimulates H_2O molecules of the well-hydrated tissue and quickly brings the H_2O to a boil. Heat is conducted to collagenous tissue that shrinks as a result of denaturation. | 0.5-1.12 mm |
| Radio-frequency (2 types) | Electromagnetic Energy | Heat produced as a result of molecular friction from the oscillation of electrolytes. | Variable depending on if the device is monopolar or bipolar and by manufacture |
| Monopolar Radio-frequency | Power boost from an outlet, Converted to AC in Generator box \rightarrow Probe \rightarrow patient \rightarrow grounding on patient's body | Heat is produced in tissue by molecular friction due to patient's tissue offering higher resistance than rest of the circuit. (Delivers energy into the tissue) | 4+ mm |
| Bipolar Radio-frequency | Heat by conduction by following the path of least resistance. | Heat is Conducted through arthroscopic fluid environment (i.e. saline) instead of through tissue. (Delivers energy away from the tissue) | 0.2-1.0 mm |

* Information compiled from: Oratec® Interventions, Inc.,¹⁵ Anderson et al.,¹⁷ and Nottage²⁹

transmission, heating of capsular tissue, depth of penetration for the Ho: YAG laser, monopolar radio-frequency, and bipolar radio-frequency surgical devices. A wand or a probe is used to deliver the thermal energy to the desired structure.

Thermal Capsulorrhaphy Surgical Technique

Thermal energy is delivered via radio-frequency for the Electrothermally-Assisted Capsulorrhaphy (ETAC) surgical procedure.⁷ The ETAC surgical procedure can now be performed on an outpatient basis. The patient is seen by an anesthesiologist, who determines the appropriate anesthesia. Interscalene regional anesthesia is the preferred anesthesia and is often accompanied by a general anesthetic. After induction of general anesthesia, an examination is performed on the patient's affected shoulder and the contralateral shoulder.^{2,3,7} Intravenous prophylactic antibiotic is also administered to the entire affected shoulder, forearm and hand.⁷ Before any surgical incisions are made, the bony anatomy is marked and the posterior and anterior portals are marked and infiltrated with 1% lidocaine and 1:2,000,000 epinephrine.

Patients are then placed in the lateral decubitus position and the shoulder and upper extremity are placed in a traction device in the appropriate position for shoulder arthroscopy.⁷ A standard posterior portal is made, and diagnostic arthroscopy of the glenohumeral joint is performed. The surgeon looks at the state of the rotator cuff, long head biceps tendon, labrum, glenohumeral chondral surfaces, and glenohumeral capsular ligaments.^{3,7} The surgeon then checks to see if a “drive through” sign is present. A “drive through” sign exists when the arthroscope placed in the posterior portal can be moved easily from posterior to anterior because of the increased distance between the

humeral head and the glenoid fossa due to capsular laxity.^{4,7} A positive 'drive through' sign confirms the diagnosis of GH joint instability.

After the examination of the anterior structures from the posterior portal, an examination of the posterior capsule and labrum is performed from the anterior portal.^{2,7} Any small tears of the glenohumeral ligaments and ligament-labrum avulsions are repaired (arthroscopic bankart and superior labral anterior to posterior (SLAP) repairs), and any partial thickness rotator cuff tears are also debrided at this time. If detachment of the posterior band of the IGHLC from the glenoid has occurred, this structure is repaired prior to starting any ETAC procedure.⁷ Upon completion of the examination of the shoulder under anesthesia and after checking the arthroscopic appearance of the capsular tissues, the decision to use ETAC and to what extent it should be used is made by the surgeon. Appropriate indications for thermal capsulorrhaphy are still being developed.¹⁷ The area of the capsule to be treated depends on the symptoms, examination findings, and the arthroscopic appearance of the capsule and ligaments.

To begin the capsular tightening procedure using radio-frequency, the thermal probe is introduced through the anterior portal and placed in direct contact with the IGHLC (Figure 7).^{2,7} The tightening begins on the posterior band of the IGHLC and continues across the inferior glenohumeral ligament and up the anterior capsule systematically tightening the middle and superior GH ligaments (Figure 8). Single passes of the thermal probe are done from the glenoid side to the humeral side of the capsule. If posterior capsular redundancy and instability exist as with MDI, then the arthroscope is then moved to the anterior portal (Figure 9), and the thermal probe is introduced through the posterior portal.^{2,7} The posterior capsular structures are then treated in a similar

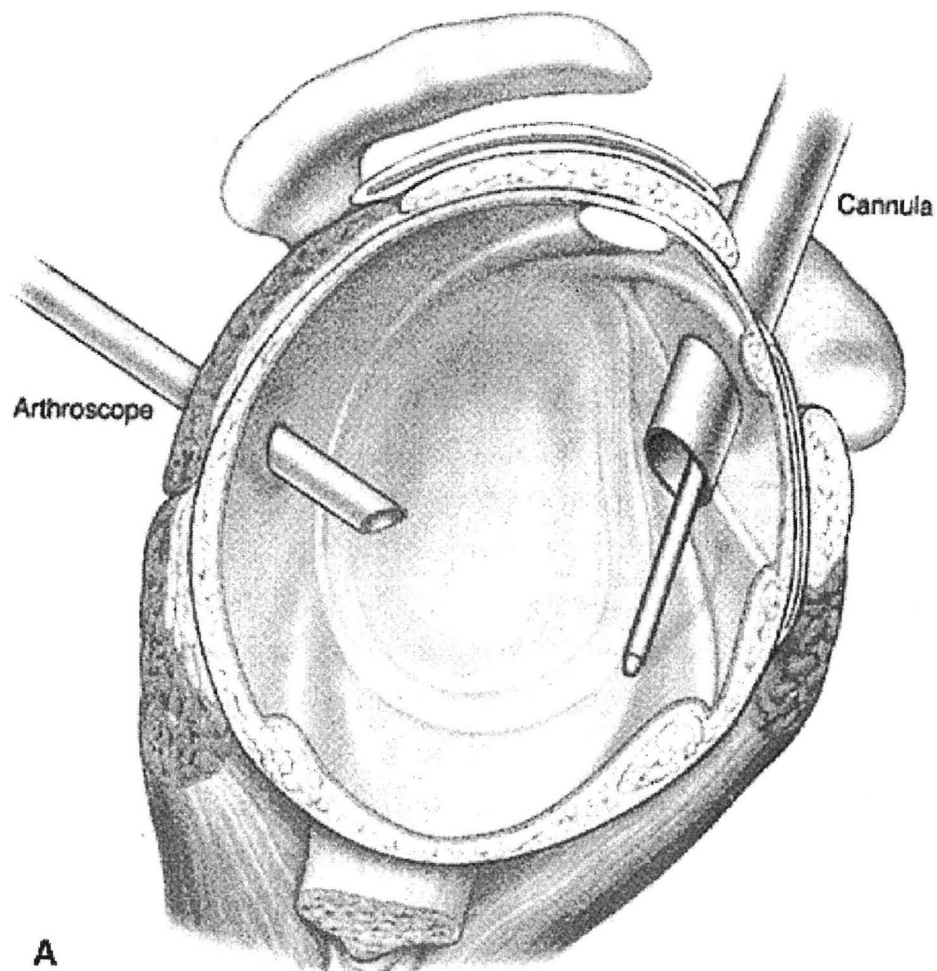


Figure 7. The thermal probe is introduced through the cannula in the standard anterior arthroscopic portal to treat anterior instability. (Reprinted with permission from: Anderson K, McCarty EC, Warren RF. Thermal capsulorrhaphy: where are we today? *Sports Medicine and Arthroscopy Review*. 1999;7:117-127.)

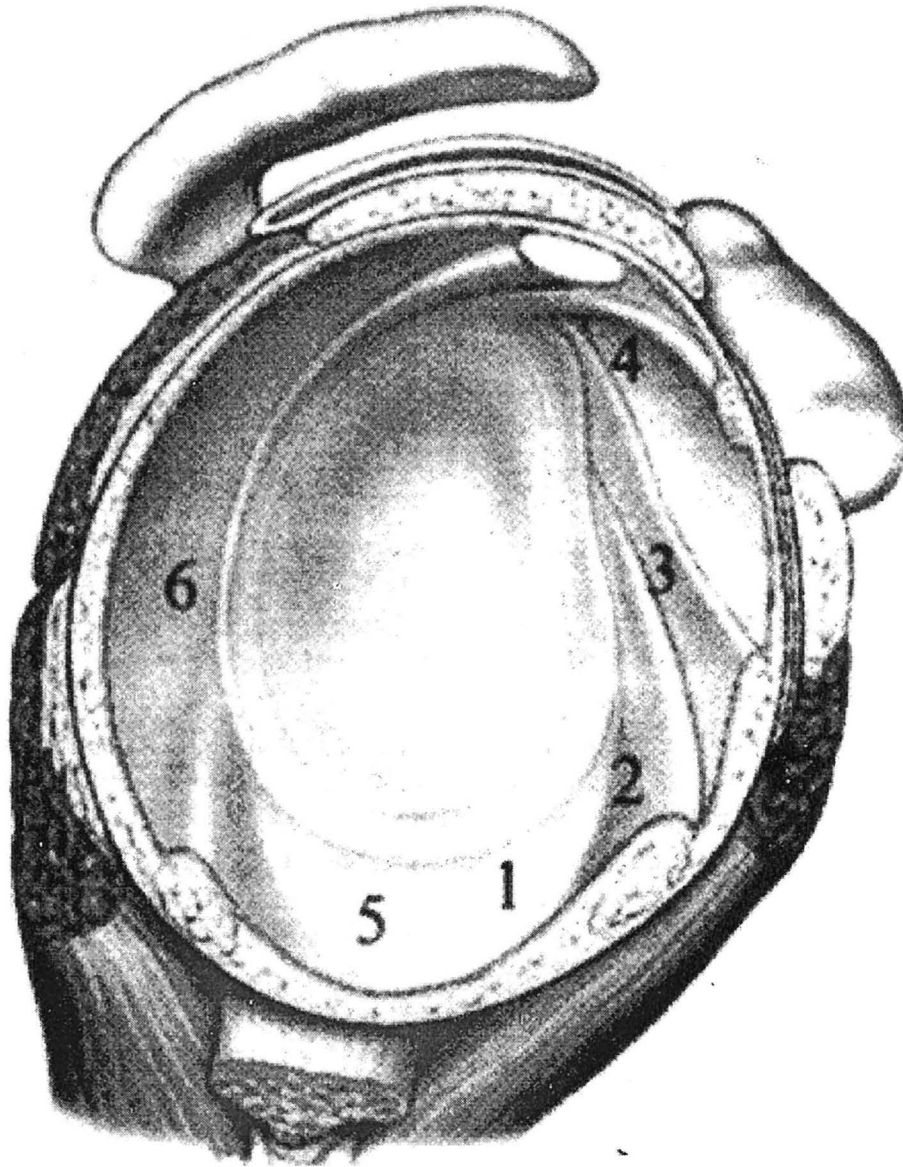


Figure 8. Thermal assisted capsulorrhaphy for multidirectional instability is performed through a combination of portals in a sequence as shown. Area 1 axillary pouch of IGHLC, area 2 anterior band of the IGHLC, area 3 MGHL, Structures in the rotator interval area 4 should be included, area 5 axillary pouch and posterior band of the IGHLC, and area 6 is the posterior GH capsule. Occasionally, the axillary pouch can be accessed through the posterior portal. If not, an accessory portal is created. (Reprinted with permission from: Anderson K, McCarty EC, Warren RF. Thermal capsulorrhaphy: where are we today? *Sports Medicine and Arthroscopy Review*. 1999;7:117-127.)

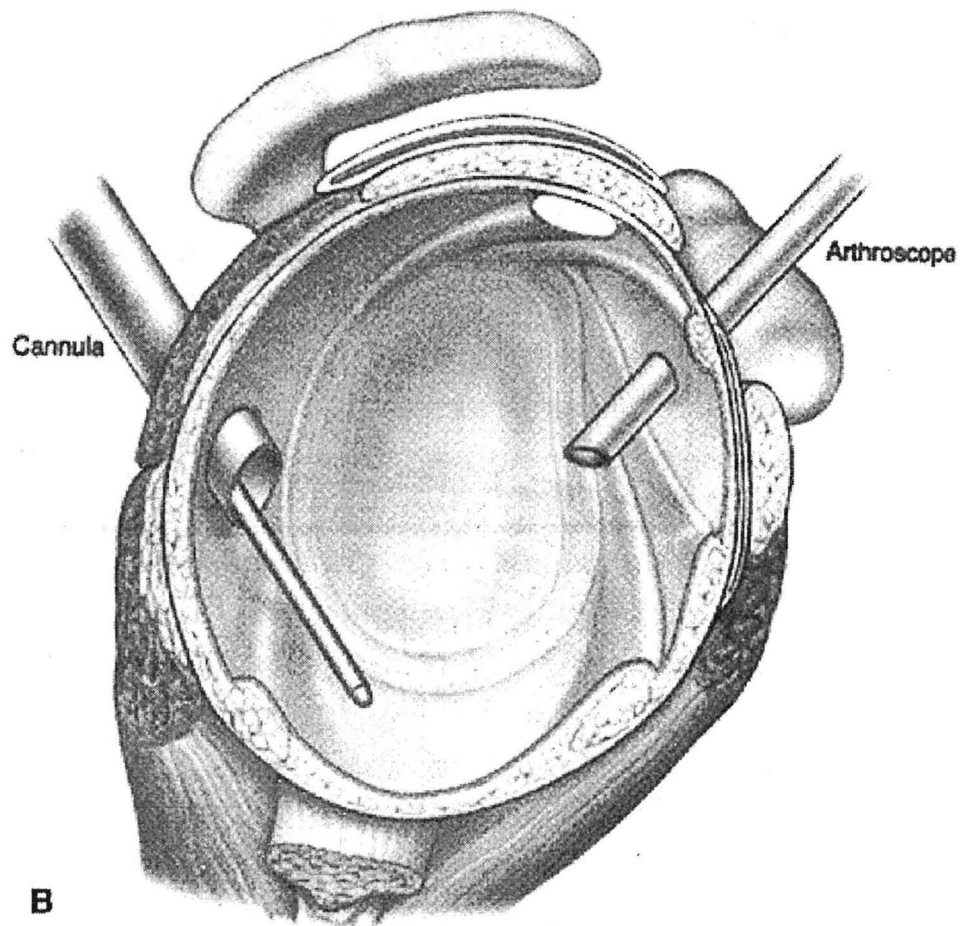


Figure 9. The thermal probe is introduced through the cannula in the standard posterior arthroscopic portal. (Reprinted with permission from: Anderson K, McCarty EC, Warren RF. Thermal capsulorrhaphy: where are we today? *Sports Medicine and Arthroscopy Review*. 1999;7:117-127.)

manner again starting on the glenoid side and making radial passes while proceeding superiority along the posterior capsule. The surgeon should continually be reassessing the amount of capsular shrinkage.⁷

During the ETAC procedure, the surgeon times the heating by watching for bubbles and actual contraction of the capsular tissue.⁷ The surgeon must also be aware that in the inferior pouch area (6 o' clock area on the labrum) the axillary nerve is at risk of being injured along with other brachial plexus structures. For this reason, access is improved to the inferior capsule by using an accessory posteroinferior portal (Figure 10), which is not a standard arthroscopic portal.¹⁷

With the radio-frequency thermal probe, the amount of heat delivered is dependent upon the time the probe is actually in contact with the tissue.⁷ This direct contact with the tissue is in contrast to the use of Ho: YAG laser procedure, where the thermal energy is applied without direct contact (free beam) with the capsular tissue.^{3,29} There are some hot tip lasers that deliver the laser energy through direct contact.²⁹ However, the hot tip laser often accumulates debris, which in turn blocks the laser energy and leads ultimately to a cautery type effect.

Currently the amount and extent of capsular shrinkage that is optimal has not been defined, and it is left up to the surgeon's judgement and experience of what appears to be normal.⁷ A few guidelines do exist for the surgeons to follow in this regard. For example, when repairing the anterior band of the IGHLC and capsule the surgeon should discontinue the thermal shrinkage when there is no longer a "drive through" sign. Also measuring capsular volume intraoperatively may be a way to determine how much shrinkage has occurred. The surgeon should also avoid reshinking areas that have

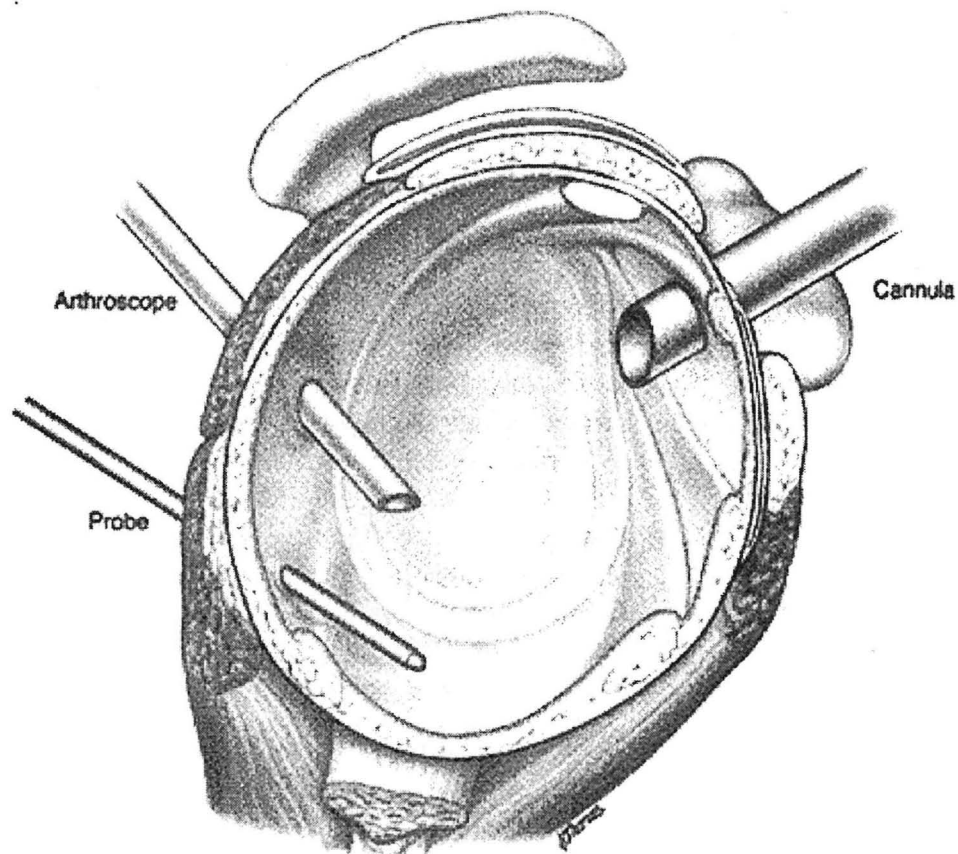


Figure 10. Improved access to the inferior capsule can be achieved using an accessory posteroinferior portal (Location of the probe). Temperatures should be monitored carefully while in this area due to close proximity to the axillary nerve. (Reprinted with permission from: Anderson K, McCarty EC, Warren RF. Thermal capsulorrhaphy: where are we today? *Sports Medicine and Arthroscopy Review*. 1999;7:117-127.)

already been treated, especially when changing portals.¹⁷ Also, the presence of a sulcus sign (dimpling of the skin below the acromion⁴) with the arm at the side suggest the presence of global laxity including the anterosuperior structures specifically the SGHL, and rotator interval. With the arm abducted, the presence of a sulcus sign requires special attention be paid to the IGHLC.¹⁷ As mentioned earlier, better access is obtained to this area through the posteroinferior accessory portal (Figure 9).

Thermal tightening of the deep and superficial layers of the rotator interval can be attempted.² However, in the majority of cases it is believed that shrinkage of the rotator interval is ineffective, possible due to the presence of the anterior operative portal. If laxity is still present in the rotator interval after attempted shrinkage, plication sutures are placed in the capsular tissue of the rotator interval. At the completion of the surgery the portals are sutured and a sterile dressing is applied.^{2,7} The patient's arm is then placed in either an abduction sling or shoulder immobilizer. The patient is now ready to begin the postoperative recovery period and the subsequent physical therapy rehabilitation process.

CHAPTER VI

POST OPERATIVE MANAGEMENT AND REHABILITATION PROTOCOL FOLLOWING THERMAL CAPSULORRHAPHY

Postoperatively, the patient's shoulder is placed in a sling or shoulder immobilizer. The position of the arm, and the length of time immobilized varies in the literature. Tyler et al.⁷ recommend that the arm be placed in internal rotation, slightly anterior to the frontal plane in a swathe for 3-4 weeks. Savoie and Field² state that the arm should be placed in an abduction sling for 1-3 weeks, but a regular arm sling may be used instead of the abduction sling after the first week. Ellenbecker and Mattalino³ feel that the sling can be removed after two weeks postoperatively. No optimal time period has been established regarding shoulder immobilization after undergoing the thermal capsulorrhaphy procedure.

The early postoperative capsular tensile strength is presumed to be weak, and thus early rehabilitation program is more conservative than are those of an open stabilization procedure.^{2,7} This is based on animal studies which suggest that thermal shrinkage of the capsule creates a shortened scaffold upon which fibroblasts migrate, invade the tissue, and lay down new collagen.⁵ The process of laying down collagen takes 4-6 weeks to begin and several months to mature. The major focus of the first four weeks of treatment is to maintain proximal and distal strength and mobility, provide pain relief, and to prevent selective hypomobility of sections of the capsule due to iatrogenic shortening

from the surgery.⁷ Some discrepancies also exist among medical professionals on the time frames for initiating range of motion (ROM), and strengthening exercises as are summarized in Table 2.^{3,7,30} It should be noted that if a posterior stabilization has been performed, the shoulder should be kept in 30° of external rotation (ER) for a minimum of 4 weeks before initiating rehabilitation.⁵ Full internal rotation (IR) should be avoided during the recovery of all posteriorly treated capsules.

Weeks 1-4

During the initial 1st four weeks postoperatively, elbow ROM and gripping exercises are greatly encouraged to minimize the effects of immobilization.^{3,7,30} To help relieve shoulder pain at night, the patient should be instructed to sleep with a pillow under their arm to take stress off the anterior joint capsule.⁷ The employment of modalities can also be useful in providing pain relief. The amount of pain, swelling and the degree of patholaxity that was treated with ETAC will determine the progression for the patient. Pendulum exercises during the immediate postoperative period are safe and should be utilized for several reasons. Pendulum exercises require very little muscular activity, offer pain relief, and help prevent adhesions from forming in the tissues. Also during the first 4 weeks, the mobility of the sternoclavicular, acromioclavicular, and scapulothoracic joints are evaluated and can be mobilized if indicated by decreased mobility. Once mobility of these proximal shoulder joints has been reached, the patient is ready to begin manual scapular stabilization exercises. Manual resistance can be given to the scapula in a sidelying position for elevation, depression, protraction, and retraction. Submaximal painfree external and internal isometrics may begin as early as 7 days after surgery at a position of 0° of abduction.

Table 2. A Comparison of 3 Recommended Physical Therapy Protocols Following Thermal Capsulorrhaphy of the Shoulder

| Time Frame | Tyler et al.Clinical Progression* | Time frame | Ellenbecker & Mattalino Clinical Progression** | Time Frame | Oratec® Recommended Clinical Progression*** |
|-------------------|--|-----------------------|--|-------------------|---|
| Weeks 0-1 | Modalities PRN for pain Gentle Pendulum exercises AROM for Elbow | Weeks 0-2 Phase I | Modalities for pain 1 st 2 weeks ROM elbows forearm and wrist Scapular mobilization Strengthening for elbow, forearm and wrist musculature No ROM to GH joint | Weeks 0-4 | Gunslinger immobilizer Wrist and Elbow ROM |
| 1-4 | Wrist strengthening Elbow strengthening with shoulder stabilized Submaximal isometrics @ 0° abduction, Sternoclavicular, acromioclavicular, and scapulothoracic mobilization, Scapular stabilization exercises | | | | |
| Weeks 4-6 | Remove Sling AAROM for flexion and IR in plane of scapula Isometric exercises in scapular plane PROM ER in scapular plane and abduction position to 70° Posterior capsule stretching Initiate ER/IR isotonics | Weeks 2-4 Phase II | Sling removed PROM GH joint from 100-120° of flexion, abduction, and scaption 45° ER Full IR Posterior glides of humeral head to help with IR allowed Submaximal isometrics for IR& ER Manual resistance for IR, ER, scapular protraction/retraction Overhead Pulleys are used to restore ROM Resistive exercises using low-resistance/high reps (3X15 reps) Upper body ergometry | Weeks 4-6 | Neutral ER to 45° and at 90° abduction Forward Flexion to 90° Extension to 20° Progressive resistive exercise of shoulder, elbow and wrist No passive stretch outside this ROM Shoulder shrugs and scapular retraction |

* . Information from Tyler et al.⁷** Information from Ellenbecker and Mattalino.³*** Information from Oratec® Interventions, Inc.³⁰

Table 2. (cont.) A Comparison of 3 Recommended Physical Therapy Protocols Following Thermal Capsulorrhaphy of the Shoulder

| Time Frame | Tyler et al. Clinical Progression | Time Frame | Ellenbecker & Mattalino Progression | Time Frame | Oratec® Recommended Clinical Progression |
|-------------------|--|-------------------------------|---|-------------------|--|
| Weeks 6-8 | Active scaption to 90° Posterior glide joint mobilization PROM of ER at 90° of abduction Start PNF patterns | Weeks 4-10 Phase III | Active and Passive ROM to end ranges in all planes Continue Posterior Glide of humeral head to restore IR Isotonic exercises using Rubber Tubing for IR and ER and scapular retraction and protraction UE plyometrics started with Swiss balls progressing to 2-6# medicine balls as tolerated using chest-pass pattern Weight bearing through shoulders: over Swiss ball, baps boards Quadruped and triped stance positions | Weeks 6-8 | Full Shoulder Rehab: Scapular patterns Deltoid IR and ER strengthening PNF patterns Wall Pulleys ER limited to 15° less than the opposite side. Remainder achieved by the patient on their own. |
| Weeks 8-12 | Full AROM (except ER at 90° of abduction) Normalize Scapulo-Humeral rhythm Strengthen shoulder muscles above abduction position of 90° Start isokinetic exercises | Weeks 10-12 Phase IV | Continue phase III exercises Isokinetic exercise for IR and ER modified base position | Week 8 | Self directed gym program PNF patterns Monitor 1-2 X per month No strenuous overhead sports or work No overhead flexion No throwing |
| Weeks 12-14 | Wall push-ups Start plyometric throwbacks | Weeks 12-16 Phase IV cont. | Progressive increases in isotonic and isokinetic rotator cuff and scapular strengthening in 90° of GH joint abduction for specificity of sport | Week 12 | Return to sports/work without restriction Caution with overhead positions |
| Weeks 14-16 | Overhead activities Begin racket/throwing program Return to Sport week 16 | Weeks 16 or longer Phase V | Return to sport when isokinetic strength is within 10% of the contralateral extremity for IR and ER Functional ROM re-attainment Negative impingement & muscle provocation tests | | |

Weeks 4-6

In weeks 4-6 following surgery, the patient is typically seen for 2-3 visits per week.⁷ The focus here should be on the return of scapular stability and GH joint ROM. As the patient progresses, rotator cuff isotonic strengthening is begun and the patient removes the sling. Active assistive range of motion (AAROM) exercises are initiated by employing the use of pulley or cane in the plane of the scapula for shoulder flexion and IR. External rotation is done with the arm at the side initially and then progressed to being performed in the plane of the scapula. Extreme caution should be used with any passive range of motion (PROM) exercises.^{7,30} This is to allow for healing and tightening of the capsular tissues. However, stretching of the posterior capsule should be emphasized if only anterior shrinkage was performed because tightness of the posterior capsule is associated with loss of IR ROM.⁷ It felt that tightness in of the posterior capsule might also lead to anterior-superior migration of the humeral head with shoulder flexion, which in turn could lead to impingement. External rotation performed passively should be limited to 45° and PROM for abduction should be limited to 70-90°.^{7,30} During this phase of rehabilitation isotonic exercise such as using rubber tubing can be initiated for shoulder flexion, scaption, ER, IR in the scapular plane.^{3,7,30} Free weights, jogging or running should be avoided during the first 4-6 weeks, to minimize the chances of detrimental humeral head translation.⁷ It is very important that the physical therapist maintain supervision of the patient during ROM progression to ensure no passive stretch outside the ROM listed above occurs in order that the healing tissue is protected.^{7,30}

In order for the patient to progress to the next phase of rehabilitation, the patient must achieve flexion in the scapular plane of 90-135°, ER in the scapular plane of 45°,

near full IR in the scapular plane and abduction of 70°. ⁷ Poor grade manual muscle testing strength in the available ROM is also suggested before advancing the patient's rehabilitation to the next stage.

Weeks 6-8

In weeks 6-8, it is recommended that the therapist continue to see the patient 2-3 times per week. ⁷ Full GH joint ROM and dynamic stability of the humeral head in the glenoid fossa should be the focus treatments. One goal is to work to achieve 90 degrees of active scaption (as defined in prevention section as abduction in the plane of the scapula). When the patient is able to get 70-80° of ER in the plane of the scapula, initiation of ER in 90° of abduction can be done. Tyler et al. ⁷ reports that full ER and IR typically does not occur usually until weeks 10-12 following the ETAC procedure.

Upper body ergometer set at light resistance is useful for helping gain ROM. ⁷ Strengthening progresses to using resistance such as elastic bands. This is done in the plane of the scapula for shoulder ER and IR as well as for abduction and extension. ^{3,7,30} It is also recommended that upper extremity Proprioceptive Neuromuscular Facilitation (PNF) patterns be used during this phase of rehabilitation. ^{7,30} The PNF patterns, which combine rotation with diagonal movements, are good rehabilitation tools because these movements closely resemble the movement patterns required for work and sport activities. It is presumed that PNF patterns also acts to enhance the proprioceptive input and neuromuscular responses, while stressing motor relearning in the postoperative phases of the rehabilitation process. ⁷ Isotonic exercise employing light resistance and increased repetitions are used for isolated and combined movement patterns of the shoulder. Tyler et al. ⁷ use a program that starts with 3 sets of 10 repetitions, progressing

to 2 sets of 15 repetitions, and then finally to 1 set of 30 repetitions. When the patient can perform 30 repetitions of a given exercise, the resistance should be increased by 1-2 pounds (0.45-0.9 kg). With each increase in resistance the patient should start by performing 3 sets of 10 repetitions, and progressing as described previously. It is also appropriate to combine isotonic exercises in functional movement patterns, which can be accomplished by having the patient perform PNF patterns with rubber tubing resistance. Before the patient progresses to the next phase of the rehabilitation process, the patient should be within 10° of full AROM in flexion, abduction, IR, and ER in the plane of the scapula. The patient's isometric strength should be at the minimum 50% of the uninvolved side, and patient should be able to perform forward flexion in plane of the scapula completing 3 sets of 10 with a 5 pound weight.

Weeks 8-12

The patient is now entering the late postoperative phase of the rehabilitation process.⁷ The patient may only be seen by a physical therapist 1-2 times per month to monitor progress.³⁰ Range of motion is now unrestricted with the exception of ER, which is limited to 90°.⁷ It is felt that the athlete will regain additional degrees of ER overtime and doesn't need to be put at risk of stretching out the capsule by therapist overpressure.^{7,30} Full stretching of the posterior capsule is encouraged if full IR has not been achieved prior to this point in the rehabilitation program.⁷ Continued strengthening exercises that include isotonic, concentric and eccentric loading of the rotator cuff and scapular stabilizers are included in the exercise program. It is appropriate to begin overhead pull downs to strengthen the latissimus dorsi as long as the pull down is performed anterior to the frontal plane of the patient. Tyler et al.⁷ also recommends

training the rotator cuff eccentrically, by having the patient face away from the wall and throw a medicine ball off a wall and catch the ball. This is good exercise for the overhead athlete because when the patient catches the ball, the posterior shoulder muscles must fire eccentrically to decelerate the arm.

Plyometric exercises are done to train the entire neuromuscular system, by generating rapid and powerful muscular contractions in response to a dynamic stretch.⁷ Plyometrics utilize the principals that stored elastic energy can be used with quick and forceful movements. Stored elastic potential is due to the myotatic stretch reflex principal. If exercise movement is too slow, as is the case with weight lifting, the stored elastic energy is dissipated and is a noncontributory force. The advantage of plyometric exercise is that the patient can generate greater muscle force than that of a concentric contraction of a muscle alone if done with rapid movement. Power development is the goal with plyometric training. Ellenbecker and Mattalino³ suggest doing upper extremity plyometrics with Swiss balls and progressing to 2-6 pound medicine balls using a chest-pass pattern. Another upper extremity plyometric progression includes starting with 2 handed side to side throws, advancing to overhead, and then to 1 handed overhead throws to maximize power development in the overhead athlete.⁷ Plyometrics may also be performed for the upper extremity using a trampoline to catch a rebounding ball.

Other strengthening exercises recommended by Ellenbecker and Mattalino³ are employing weight bearing activities through the shoulders over a Swiss ball, baps boards, or quadruped and triped stance positions. Isokinetic training and testing may be performed progressing from the modified neutral position, to a functional shoulder

abduction position with 90° of elbow flexion⁷ This allows for strengthening in a functional position for sport.

Criteria for Return to Sport

There are several criteria that need to be met before the athlete is allowed to return to sport. The athlete is permitted to return to sport gradually once they are pain-free, and have near full ROM in all shoulder motions.^{3,7} The athlete must also have confidence in the shoulder, which is achieved when the patient has pain-free, functional movement required for their sport.⁷ Eighty-five to 90% of strength as compared to the uninvolved side using isokinetic testing at 180, 300, 450°/sec for the motions of IR and ER is recommended for return to sport.^{3,7} Additional criteria include negative impingement tests, and muscle tendon provocation tests.³ Tyler et al.⁷ have found that the athlete who uses throwing motions for sport performance requires 1-2 months more time to acclimate to the motion than the non-throwing athlete. Other factors that may influence an athletes return to sport is if additional surgical procedures such as reattachment of the labrum, ligaments, or the biceps tendon were performed in conjunction with thermal capsulorrhaphy procedures. Rehabilitation for these procedures progresses much faster due to strong fixation techniques, than they do for the thermal capsulorrhaphy procedure alone.

Clinical Outcomes

Since 1997, Tyler et al.⁷ have treated 75 patients with a mean age of 26 ± 4 years following the guidelines listed in Table 2. Their short-term outcomes seem to be favorable for the ETAC procedure in reducing GH joint instability, as only 5 patients have returned with hypermobility. Three of these patients seen were treated under the

guidelines that indicated removal of the sling one week postoperatively and full ER ROM by 6 weeks. All three of these patients required additional surgery to perform an inferior capsular shift to tighten the capsule. A baseball pitcher with full ROM but pain during throwing also required an inferior capsular shift. Of the 75 patients treated with this surgical procedure, 2 were professional and 10 were division 1A pitchers, and 2 were semiprofessional tennis players. All 14 of these athletes returned to their previous level of competition without further instability.

Anderson, McCarty, and Warren¹⁷ have treated over 80 patients with thermal capsulorrhaphy at The Hospital for Special Surgery, New York, NY. Short-term follow-up indicates quite good results as a majority of patients have been able to return to their pre-injury level of competition, which is quite remarkable given the very low tolerance for morbidity in this patient population. Patient satisfaction on the Shoulder Rating Questionnaire was found to be significantly improved over pretreatment values. Currently the direction and the degree of instability do not appear to have a significant effect on outcome after thermal capsulorrhaphy. The data also does not show a significant difference between those who have had a combination of an arthroscopic labral repair with capsular shrinkage and those who had only the capsular shrinkage done. However, the question that still remains to be answered is will the athlete be able sustain their level of competition over the long run.

Fanton⁵ reports a 90% success rate at a 2-year follow-up for 54 patients treated with radio frequency thermally assisted capsulorrhaphy procedure. Two-thirds of the patients were treated with thermal capsulorrhaphy procedure alone, while the remaining third had the thermal shrinkage performed in conjunction with fixation of the capsule to

the glenoid rim. Six of the 54 patients have had fair or poor results. Of these 6 patients, one had multidirectional instability, and a second had a large Hill-Sachs lesion posteriorly. The other 4 patients with fair to poor results, no explanation was provided regarding their results. Fanton⁵ has also noted 2 complications with this patient population. One patient developed adhesive capsulitis, while a second patient developed axillary neuritis postoperatively. However, both of these patients with complications were able to make a full recovery.

Ellenbecker and Mattalino³ have reported favorable results for strength and ROM 12 weeks postoperatively using the rehabilitation program outlined in Table 2. Their patients were treated for anterior shoulder instability using the Ho: YAG laser. Small deficits for abduction, ER and IR were measured when compared to the non-operative shoulder. External rotation and coronal plane abduction showed the greatest restriction among the analyzed motions. Isokinetic testing was used to measure ER and IR strength at 12 weeks postoperatively for 20 patients. Isokinetic tests for ER measured in the scapular plane revealed symmetric shoulder strength in 7 patients tested at 300°/sec, while 12 patients had symmetric shoulder strength tested at 90°/sec. For IR, 4% deficits were found in strength at the slowest testing speed (90°/sec) and 5% greater strength was found at two faster speeds, 210 and 300°/sec respectively. A successful outcome criterion was re-attainment of strength equal to or greater than the non-operative shoulder. This criterion was met at 12 weeks postoperatively by 9 of 20 patients for ER and 10 of 20 patients for IR. The ER to IR ratios, which ranged from 59% to 66%, suggest a slight muscular imbalance when healthy shoulders report a 66% ER to IR ratio. As stated before, more long-term research is needed to determine patient satisfaction and

to objectively quantify GH joint strength and stability following thermal capsulorrhaphy of the shoulder.

CHAPTER VII

CASE STUDY OF A COLLEGIATE TENNIS PLAYER WHO UNDERWENT THERMAL CAPSULORRHAPHY TO REDUCE SHOULDER INSTABILITY

Demographic Data and Screening Criteria

A right arm dominant 19-year-old male collegiate tennis player was selected for this study because he met the following criteria: 1) the subject had undergone the thermal capsulorrhaphy procedure to treat the diagnosis of shoulder instability, 2) the subject received physical therapy to rehabilitate his shoulder postoperatively, 3) the subject was an overhead athlete for whom shoulder stability is needed for sport participation, and 4) the subject was willing to request photocopies of his medical records regarding the surgical procedure and the subsequent physical therapy rehabilitation for the purpose of this study. The Institutional Review Board at the University of North Dakota, Grand Forks, ND granted approval for this project-project number IRB-200011-107 (Appendix A).

Subject Evaluation and History

During the fall of the 1998 tennis practice season, the subject in this study reported a slow insidious onset of right shoulder pain with popping, especially when reaching across his body or when performing overhead tennis strokes such as the serve. The subject states that the pain was primarily located posteriorly although there was an anterior component as well. The subject denied any specific injury or previous bouts of

shoulder pain or instability. The subject was diagnosed preoperatively by an orthopedic surgeon with anterior inferior instability of the right shoulder during the 1999 spring tennis season. The orthopedic surgeon provided the subject with a copy of a home exercise program, however no referral was made to physical therapy. In addition to the home exercise program, the orthopedic surgeon administered two cortisone shots to the subject's right shoulder approximately 4 weeks apart. After a 2-month attempt to rehabilitate the shoulder was unsuccessful, the subject was offered the option of undergoing the thermal capsulorrhaphy procedure to tighten his loose GH joint capsule.

Intra-operative Findings

The subject was placed under general anesthesia, and preoperational examination was performed, which confirmed anterior inferior shoulder instability. The orthopedic surgeon noted that the majority of the instability was straight anterior, and that the subject did not have much of a sulcus sign and had minimal posterior instability. Upon insertion of the arthroscope through the routine posterior portal, the surgeon noted the subject to have a lot of laxity and redundancy of both the anterior superior and anterior inferior capsule, with a positive drive through sign. The subject was also noted to have a poorly defined anterior band of IGHLC, but the rest of the capsular tissue was otherwise in good condition. No SLAP lesion was identified. The surgeon proceeded with the capsular shrinkage using the Oratec® Tac-C thermal probe. The technique was performed using what the surgeon described as “corn rows” starting from approximately 5 o’clock to 5:30 position on the labrum and progressing superiorly up to about the 3:30 position. Once a series of 3 “corn rows” were made, capsular shrinkage to the anterior superior capsule was done along the biceps tendon. Mild erythema and fraying was identified under the

anterior superior rotator cuff, as well as the posterior cuff. The presence of a mild positive drive through sign was still present, so the surgeon made 2 more “corn rows” along the anterior IGHLC and then placed the arthroscope through the anterior superior portal to examine the posterior capsule. The posterior capsule revealed a moderate degree of capsular redundancy with some synovitis and injured posterior rotator cuff tissue. The surgeon then proceeded to shrink the capsule tissue posteriorly and posterosuperiorly. Once this was complete, the arthroscope was removed and significant tightening with improved ligament stability in the 90° externally rotated position with less total mobility and anterior excursion was noted intra-operatively. Steri strips were used to close the portals followed by intra-articular Morphine and Marcaine with epinephrine. The subject’s right shoulder was then placed in a sling and the subject was returned to the recovery room in satisfactory condition.

The day after surgery the subject was instructed by his surgeon in Codman’s pendulum exercises and resisted isometric exercises for IR, ER, flexion, and extension at 0° of abduction. These exercises were to be performed 3 times per day. The subject was also instructed to wear his sling for two weeks and to use ice to help with pain relief. The subject was not given a prescription to see a physical therapist until 4 weeks had passed and was not seen by a physical therapist until 6 weeks post surgery. The surgeon provided the therapist with the general exercise protocol that is outlined below.

Initial Physical Therapy Evaluation Findings

The subject was noted to have some atrophy of the right shoulder girdle upon examination along with some crepitus in his right posterior shoulder. No special tests were performed on the shoulder by the physical therapist. Range of motion for the right

shoulder showed some deficits when compared to left shoulder ROM. The subject also demonstrated a substitution pattern with active shoulder abduction. Right shoulder IR, followed by extension showed the greatest deficits at 74% and 78% respectively in comparison to left shoulder ROM. Right shoulder flexion and abduction measured 87% and 88% respectively in comparison to left shoulder. However, the initial measurement of ER on the right shoulder revealed excessive movement, measuring to be 102% when compared to the left shoulder. Elbow flexion was within functional limits bilaterally, while right elbow extension showed a deficit of 14°, while left elbow extension measured 0°. Strength was tested on the left upper extremity and on the right upper extremity in neutral/midrange positions. No strength deficits were noted when measured in these midrange positions. The physical therapist's prognosis for the subject was stated as good.

Physical Therapy Treatment and Goals

The subject was seen 2 times per week for supervised physical therapy visits for duration of 9 weeks. The subject was also instructed in a home exercise program. The protocol provided by the surgeon at 4 weeks post surgery was as follows: strengthening was to be done before pushing ROM. Strengthening exercises were to be done for the scapular stabilizers and rotator cuff muscles in a safe range progressing slowly to combined abduction with ER. In addition, strengthening was to progress to the biceps, triceps, and deltoid musculature. Active range of motion was also to be initiated using pulleys and rowing. Following at least two weeks of closed chain strengthening exercises plyometrics were to be initiated by week 10. Last, light throwing program was to be initiated during weeks 12-14 post operatively.

The PT treatment plan was to follow and instruct the subject in a home exercise program as per doctor's protocol including possible aquatic exercises. The short-term goals were set to be achieved in 2 weeks by this subject were to strengthen the subject in neutral ranges without complaints of pain, and to gain full AAROM without pain or substitutions. Long-term goals set to be achieved in 4 weeks for this subject included full ROM, functional strength without crepitus and independent with stage two goals.

Weeks 6-7

The subject's treatment starting 6 weeks post surgery included 2 pound weights in side lying position for IR and ER. The subject was also started on isometrics for pectoral muscles and scapular stabilization exercises. Pulley exercises were performed for the shoulder extensors starting with 10 pounds progressing to 20 pounds, while biceps and triceps performed bilaterally using 20 pounds of resistance. Shoulder shrugs were completed using 5 pound weights bilaterally, and closed chain upper extremity exercise consisting of mini pushups were also initiated. The subject also performed shoulder short arcs in supine with 2 pound weight and serratus anterior presses lifting 5 pounds. The subject performed 3 sets of 10 repetitions of each of the exercises described above. In week 7, the subject started each therapy session with a 12-15 minute warm-up on the Aerodyne (upper body ergometer).

Weeks 8-9

Subject discontinued performing isometric strengthening of pectoral musculature. However, the subject did continue to perform all of the other exercises as in described in weeks 6-7. The subject was progressed to IR and ER on pulleys with 10 pounds of resistance and repetitions for all other exercises were progressed to 3 sets of 15

repetitions. Resistance was also increased to 4 pounds for supine shoulder short arcs, and to 8 pounds for shoulder shrugs and to 25 pounds for triceps strengthening on pulleys.

Weeks 10-11

The same core exercises were continued from weeks 8-9 with the exception of the discontinuation of the scapular stabilization exercises of elevation/depression and retraction and protraction. However, the subject continued to perform mini pushups (3 X 25 repetitions) and in week 11 the subject began performing mini pushups with extra protraction. Serratus anterior press resistance was increased to 6 pounds. Resistance was also increased for internal rotation from 10 pounds to 20 pounds. Supine shoulder short arcs poundage was increased to 5 pounds. Starting in week 11, the subject began supine head to toe 9 pound ball toss, times 35 repetitions and supine vertical ball toss with 9 pound ball, times 30 repetitions. Also in week 11, the subject began performing a few pushups from his knees. At the end of week 11 the subject initiated upper extremity D₁ and D₂ PNF patterns with manual resistance times 40 repetitions.

Weeks 12-14

A re-evaluation was performed at the start of the 7th week of physical therapy rehabilitation (week 12th postoperatively). "No significant change in condition" was noted in the subject's chart. Subjectively the subject stated that his home exercise program was going well, and that he only experienced pain with ER to neutral. The pain was located in the posterior right shoulder, but no crepitus was noted by the therapist. The treatment plan was to increase the amount of closed chain strengthening, and to initiate plyometrics exercises. The treatment plan also called for the initiation of light throwing activities in weeks 12-14 and to continue therapeutic exercises and endurance

activities and to increase stretching. Assessment showed that there was still an overall decrease in right upper extremity flexibility. Active range of motion of the right shoulder was limited to 136° of flexion, and 132° of abduction. No left shoulder ROM was recorded. Active right elbow extension was lacking 14-20° and supination of the right forearm was lacking approximately 15°. No strength deficits were noted and biceps strength was noted to be exceptionally strong. The new short-term goals set for the subject included a decrease biceps tightness to decrease subject's right elbow contracture to 10° and to make sure the subject was independent with his home exercise program. The long-term goals that were set to be achieved in 4 weeks included progression of the subject to within functional limits for the right upper extremity, and to return the subject to activity (tennis). Prognosis was stated as "good for goals".

The subject continued to perform the core exercises from weeks 10-11 with the following modifications. Warm-up was completed on the Aerodyne as before, but alternated grip between supination and pronation was made half way through the warm up. The subject continued strengthening pulley exercises for biceps, triceps, shoulder extensors, ER, and IR. The subject also continued to do upper extremity D₁ and D₂ PNF patterns and plyometric training completing supine ball toss, head to toe, and vertical toss. Bicep, tricep, and IR, and ER stretches were added to the program. At the end of week 12 the subject was instructed in light throwing exercises. Week 14, the subject was allowed to play tennis very mildly and to limit serves to 15 repetitions. Subject performed backhand and forehand swings with his tennis racket and ball with therapist supervision. At the end of week 14 the subject discharged himself from physical therapy to return to the fall semester of college. Final right shoulder strength was recorded as

4+/5 for shoulder abductors, and 4-/5 for shoulder flexors. Final AROM measurements for the right shoulder were 165° of shoulder flexion, which was 29° improvement from the initial evaluation, and was 106% of left shoulder flexion as measured on the initial evaluation. Shoulder active abduction on the final visit was measured to be 145°, a 36° improvement and this was determined to be 90% of available left shoulder abduction as measured initially. The subject continued to have right shoulder biceps tightness, and no significant improvement was noted for right elbow extension at the time of discharge.

18 Months Post-operatively

The information presented in this case study was obtained from a personal questionnaire and from the subject's medical records regarding his surgery and physical rehabilitation. This study was conducted just over 18 months after the subject underwent thermal capsulorrhaphy to his serving shoulder. At the time this study was conducted, the subject had not returned to playing tennis at the collegiate level. The subject stated that after he finished his physical rehabilitation that his right shoulder felt "a little weak" and that "it was significantly weaker than his left shoulder." The subject reported that his shoulder felt fine until he attempted to start playing overhead sports again, and stated, "In fact I was having different pains than I had felt in the past." As a result of these new pains, the subject was not satisfied with the outcome of the surgery and physical therapy program and this ultimately led the subject to seek a second opinion 5 months post-operatively, and a third opinion 6 months postoperatively on his right shoulder. Ten months after undergoing thermal capsulorrhaphy procedure the subject underwent a combined open and arthroscopic surgery to his right shoulder to repair instability of the long head of the biceps tendon (biceps tenodesis), a tear of the subscapularis

(superolateral edge), and debridement of type I SLAP lesion. After undergoing a second shoulder surgery, the subject was still not able to make a complete return to playing collegiate tennis, and he attributes this to his inability to serve overhead at or near his premorbid level. Furthermore this subject's return to tennis was impeded by a knee injury in which the subject suffered a complete tear of his left anterior cruciate ligament (ACL) 10 months after his thermal capsulorrhaphy surgery. The surgical repair of his ACL was completed 14 months after thermal capsulorrhaphy surgery. After experiencing 2 shoulder surgeries and 1 knee surgery, the subject was determined to make a return to playing collegiate tennis and was in the process of doing so at the time of this study.

Discussion

There are several limitations to this case study. The first limitation is that the researcher of this case study was not one of the persons who treated this subject in the physical therapy setting following the surgical procedure. A second limitation of this study is that it is subjective in nature, and is dependent on the subject's memory of the experience from 18 months previously and on the treating physician's and physical therapists' documentation. A third limitation to this study lies in the ability to generalize the results of this case study to the athletic or general population.

However, there are also some advantages to this study. First, it allows for a retrospective investigation of one subject in an attempt to look at a more long-term clinical outcome. Long-term outcomes for this patient population are not reported in the literature at this time, nor does the data exist to suggest what the long term outcomes may show from any current studies.^{2,7,17} A second advantage to this study, is that it allows the subject's rehabilitation to be compared to other suggested rehabilitation protocols for

thermal capsulorrhaphy. A third advantage of this study is that it allows for a subject's perspective on the procedure and subject's satisfaction on the subsequent physical therapy rehabilitation process.

In general, the subject's rehabilitation followed the general principals as outlined in the suggested protocols proposed by Tyler et al.,⁷ Ellenbecker and Mattalino,³ and the thermal probe manufacturer Oratec® Intervention Inc.³⁰ (see chapter 6 and Table 2.). The most prominent feature of this subject's recovery was that he received no direct physical therapy supervision for six weeks post-operatively. The time interval between surgery and the initiation of therapy was in part due to the subject having surgery at the end of his spring semester and then traveling 800 miles back to his home state a day after surgery for summer vacation. The subject was on his own, performing pendulum exercises and resisted isometrics without any professional guidance. The only benefit of not going to therapy soon after surgery is that it may have protected the subject from receiving too aggressive of therapy too early. However the benefits of seeing a therapist outweigh the disadvantages, especially when dealing with a subject that was 19 years old and leads an active lifestyle. One very important reason for early PT intervention is to provide patient education. Patient compliance with a period of relative immobilization during the first few weeks following thermal capsulorrhaphy is very important due to the scientific evidence that suggest collagen is weak⁷ approximately day 5 to day 20 postoperatively.² The subject in this study self reported that he was instructed by his surgeon to wear his sling for only the first two weeks post-operatively. This may have been too short of an immobilization period even if compliance was good, thus leading to

some re-stretching of the GH capsule and a contributing factor to the less than satisfactory results seen in this subject's clinical outcome.

When all things are considered, the subject's shoulder appeared to be in decent condition when he was initially evaluated 6 weeks postoperatively by a physical therapist. The exercises he performed were for the most part were appropriate to the provided surgeon's protocol and to suggested protocols found in the current literature regarding thermal capsulorrhaphy. Nonetheless, one exception should be brought to light. The exception is a question of the appropriateness of performing resisted shoulder extension with a pulley. The subject was performing what was described as shoulder extensor pulls with a pulley using 10-20 pounds of resistance initially at week 6 postoperatively. The mere act of shoulder extension is only going to force some anterior translation of the humeral head in the glenoid fossa, and place stress on the anterior GH capsule. At six weeks post treatment, new collagen is just beginning to be laid down and the amount of time to reform a "normal" GH capsule is unknown at this time.² Taking this into account, the opinion of the researcher in this case study is that the risk of re-stretching the anterior capsule is too great at this point in the collagen re-formation process to be performing resisted shoulder extension exercises. To further support this position Oratec®³⁰ recommends limiting shoulder extension ROM to only 20° up until week 6 postoperatively, and does not even mention shoulder strengthening into a position of extension.

Another possible source of less than satisfactory results in this case study, was that the subject was treated in the physical therapy setting by a 5 different people, one of whom was a physical therapist, and the other 4 being physical therapy assistants. This

may not have lead to the best continuum of care, and resulted in greater variability in the inter-relater reliability of objective measures such as manual muscle testing and ROM measurements. Poor inter-relater reliability may in part explain why the subject's discharge AROM for shoulder flexion was now 106% of the uninvolved extremity. The subject in this study responded to the question of what could have been done better regarding PT rehabilitation by stating he believe that the therapist(s) treating him lacked knowledge of how to exactly rehabilitate his shoulder following this procedure. If the therapist did not have this subject's trust and confidence, compliance with a home program may have been compromised, and may have lead to a less than optimal result. In addition, the treating therapist in this study neglected to document anywhere in the subject's chart, the subject's summer occupation during the rehabilitation process. The subject was employed for the summer on his uncle's farm. He started working five weeks post operatively. Some patient education about what he could functionally do in a safe manner should have been addressed for this subject. The physical demands of farm work may also have been a contributing factor to the less than satisfactory results seen for this subject.

Short-term clinical reports for thermal capsulorrhaphy of the shoulder seem to be favorable. As discussed in chapter 6, reports of success rates at a 2 year follow up for patients treated with radio-frequency probe like the one used in this study have shown a success rate that has exceeded 90%.⁵ Six of the 54 people in that study were reported to have fair to poor results. One failure was thought to be due to "under treatment" of the capsule for a patient with MDI. Since this surgical technique is relatively new, a surgeon's experience may influence both short-term and long-term clinical outcomes as

both “under treatment” and over exposure of capsular tissue to thermal energy can result in poor clinical outcomes. The surgeon’s experience with the thermal capsulorrhaphy surgical procedure was unknown in this case study, thus the researcher is unable to speculate on whether this may have played a role in this subject’s clinical outcome.

Further clinical research is indicated for patients who have undergone thermal capsulorrhaphy to their shoulder to repair shoulder instability. Some research is currently underway. Tyler et al.⁷ are using the American Shoulder and Elbow Surgeons Shoulder Evaluation Form to standardize the documentation of strength, stability, and function in this patient population. These researchers are in the process of gathering data to determine a criterion score to clear athletes for a return to sport. Their early experience has demonstrated that the throwing athlete requires an additional 1-2 months more rehabilitation to allow the shoulder to acclimate to the motion. Although much of the literature supports this surgical procedure, this case study shows that the results are not always optimal. The subject in this study has not been able to return to performing the overhead strokes required in the sport of tennis and function at his premorbid level. Although thermal capsulorrhaphy is still evolving, the majority of candidates considered for thermal shrinkage procedure are young athletes similar to the one presented in this case study. These young athletes have the common mentality of “quicker, stronger, faster is better,” thus making compliance a challenge with this patient population. It appears that good patient compliance with a rehabilitation program, and early ROM supervision especially by a physical therapist are key components to a successful clinical outcome following thermal capsulorrhaphy of the shoulder for the young athlete. Only time will

tell how long those with favorable results will be able to maintain their previous levels of sport participation and function.

CHAPTER VIII

CONCLUSION

Shoulder instability is a common problem seen clinically in both the general and athletic populations. The shoulder is prone to injury because it sacrifices stability for mobility. Glenohumeral joint stability is provided mainly by the capsular, ligamentous, and muscular structures that surround the joint. Dynamic stability is primarily provided by the rotator cuff mechanism and through neuromuscular control. Athletes who use overhead movement patterns as an essential element of sports performance are especially at risk for developing GH joint instability. Pink and Jobe³¹ believe that shoulder instability and impingement are not 2 separate diseases, but rather are a part of a continuum. Shoulder instability with impingement often arises in the young athlete because of an overuse injury, which leads to microtrauma of capsular structures, followed by instability, then subluxation, until they experience painful impingement and possibly even a rotator cuff tear. In this continuum the athlete often does not seek medical attention until experiencing pain from internal impingement and athletes are often unaware of any GH joint instability. The athlete is initially treated with conservative physical therapy, rest, and activity modification. When conservative physical therapy treatments fail to stabilize the shoulder joint within 3 months, generally surgery is indicated to reduce redundant capsular tissue.

Several surgical interventions exist for the treatment of an unstable shoulder. Open and arthroscopic surgical techniques have been used to repair instability of the shoulder GH ligaments and capsule. However, open surgical techniques result in high morbidity and require prolonged rehabilitation. Arthroscopic surgical procedures have higher failure rates than open surgical techniques and require extreme technical expertise. Recently, thermal capsulorrhaphy of the shoulder has been offered as an alternative to the open and arthroscopic surgical techniques. Thermal capsulorrhaphy works on the principal of shrinking redundant capsular tissue by heating the tissue to the point where the collagen in the tissue becomes denatured prompting scar formation to tighten the capsule. This surgical technique is still relatively new and the indications for thermal capsulorrhaphy procedure are still evolving. Currently, both the laser and radio-frequency devices are used by surgeons to deliver the thermal energy.

There are numerous published reports describing the effects of thermal energy on joint capsular tissue, but only a few clinical outcome studies have been published regarding thermal capsulorrhaphy of the shoulder. The initial reports of this surgical technique seem to be favorable for reducing shoulder instability in the overhead athlete and general population, but no long-term studies have been done to determine the efficacy of this surgical intervention. However, as was discussed previously in the case study of one collegiate tennis athlete, the long term clinical outcomes for thermal shrinkage procedure are not always favorable. The poor clinical outcome for the subject was felt to be attributed to several factors. These factors included the following findings: there was only a 2 week immobilization period postoperatively, no physical therapy intervention for the first six weeks postoperatively, the subjects performance of resisted

shoulder extension exercises only six weeks postoperatively, the poor continuum of care in physical therapy, and the failure of the treating therapists to gain the patient's confidence in treating this diagnosis. At 18 months postoperatively, the patient had not yet returned to playing collegiate tennis.

A physical therapist's understanding of the maturation of collagen is imperative in designing a rehabilitation program for patients who have undergone the thermal capsulorrhaphy procedure. Initially, immobilization of the GH joint is necessary to avoid stretching out the capsule, because of weakness of the denatured state of the collagen. The physical therapist must monitor the patient's ROM carefully during treatments and proceed with caution to avoid re-stretching the capsule. Educating the patient and patient compliance to limitations regarding ROM are imperative for a successful clinical outcome. Pushing the patient too quickly may be the main reason for failure after this procedure since the ultimate tensile strength of the tightened capsule is unknown at this time. No one suggested treatment protocol has been proven to be superior over another. The ultimate goal when designing a rehabilitation program for this patient population is to ensure that the patient has the best chance at returning to their previous level of function, whether it be work or overhead sports. The information presented here has been written to further the physical therapist's knowledge base regarding the rehabilitation process for the patient who has undergone the thermal capsulorrhaphy procedure for the shoulder. However, long-term clinical outcomes will ultimately determine if this procedure will become the gold standard for treating shoulder instability.

APPENDIX A

REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

Date: November 20, 2000 Project Number: IRB-200011-107
Name: Kelsey Kean; Sue Jeno Department/College: Physical Therapy
Project Title: Thermal Capsulorrhaphy of the Shoulder: Literature Review and Clinical Outcome for One Collegiate Tennis Player

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on November 24, 2000 and the following action was taken:

☐ Project approved. EXPEDITED REVIEW Category No. _____
Next scheduled review is on: _____

☒ Project approved. EXEMPT REVIEW Category No. 2
This approval is valid until May 15, 2001 as long as approved procedures are followed. No periodic review scheduled unless so stated in the Remarks Section.

☐ Project approved PENDING receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. This study may NOT be started UNTIL final IRB approval has been received. (See Remarks Section for further information.)

☐ Project approval deferred. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project denied. (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

PLEASE NOTE. Requested revisions for student proposals MUST include adviser's signature.

cc: Sue Jeno, Adviser K Smart 11-24-00
Chair, Department of Physical Therapy Signature of Designated IRB Member Date
UND's Institutional Review Board

Dean, School of Medicine
If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.
(6/2000)

☒ EXPEDITED REVIEW REQUESTED UNDER ITEM 8 (NUMBER[S]) OF HHS REGULATIONS
☐ EXEMPT REVIEW REQUESTED UNDER ITEM _____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED
PROJECTS INVOLVING HUMAN SUBJECTS

Please include ALL information and check ALL blanks that apply.

PRINCIPAL

INVESTIGATOR: Kelsey Kean, Sue Jeno TELEPHONE: 777-3662 DATE: 10-11-00

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: Box 9037

SCHOOL/COLLEGE: Medicine DEPARTMENT: Physical Therapy PROPOSED PROJECT DATES: 10/11/00-5/15/01
(E.g., A&S, Medicine, EHD, etc.) (Month/Day/Year)

PROJECT TITLE: Thermal Capsulorrhaphy of the Shoulder: Literature Review and Clinical Outcome For One Collegiate Tennis

Player

FUNDING AGENCIES (IF APPLICABLE): N/A

TYPE OF PROJECT (Check ALL that apply):

☒ NEW PROJECT ☐ CONTINUATION ☐ RENEWAL ☐ DISSERTATION OR THESIS RESEARCH ☒ STUDENT RESEARCH PROJECT
☐ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Sue Jeno, Ph D, PT

PROPOSED PROJECT: ☐ INVOLVES NEW DRUGS (IND) ☐ INVOLVES NON-APPROVED USE OF DRUG ☐ INVOLVES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATION, PLEASE INDICATE THE CLASSIFICATION(S):

☐ MINORS (<18 YEARS) ☐ PREGNANT WOMEN ☐ MENTALLY DISABLED ☐ FETUSES ☐ PERSONS WITH MENTAL RETARDATION
☐ PRISONERS ☐ ABORTUSES ☐ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ☐

IF YOUR PROJECT HAS BEEN/WILL BE SUBMITTED TO ANOTHER INSTITUTIONAL REVIEW BOARD(S), PLEASE LIST NAME OF BOARD(S): _____

Status: ☐ Submitted; Date _____ ☐ Approved; Date _____ ☐ Pending

1. **ABSTRACT:** (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.) Instability of the shoulder capsule is a clinical problem in both the athletic and general population. When conservative physical therapy treatments fail to stabilize the shoulder joint, surgery is indicated. Recently thermal capsulorrhaphy, an arthroscopic procedure that uses a heat probe to shrink redundant capsular tissue, has been offered as one alternative to tighten the lax shoulder capsule. There are numerous published reports describing the effects of thermal energy on joint capsular tissue, but only a few clinical outcome studies have been published regarding thermal capsulorrhaphy of the shoulder. Some initial reports of this surgical technique seem to be favorable for reducing shoulder instability in the overhead athlete and general population, but no long-term studies have been done to determine the efficacy of this surgical intervention. The purpose of this independent study is to interview one collegiate tennis athlete who underwent the thermal capsulorrhaphy procedure to his shoulder and review his physical therapy records. The information obtained from the subject will help contribute to the physical therapist treatment and knowledge base regarding clinical outcomes as a result of this new surgical procedure and provide a patient's perspective regarding the rehabilitation process.

PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary. Attach any surveys, tests, questionnaires, interview questions, examples of interview questions (if qualitative research), etc., the subjects will be asked to complete.)

A subject, who meets the following criteria for this case study will be recruited from known athletes who participate in a high level of tennis competition. The criteria are: 1) the subject underwent the thermal capsulorrhaphy surgical procedure for shoulder instability, 2) the subject received physical therapy treatment postoperatively to rehabilitate the shoulder, 3) the subject is an overhead athlete, and 4) the subject is willing to obtain a photocopy of their medical records regarding the surgical procedure and the subsequent rehabilitation process. The subject will have already completed their physical therapy rehabilitation for the thermal capsulorrhaphy surgical procedure, thus this study is not experimental.

Upon receiving signed consent, the subject will be sent a copy of the attached interview questions and will be asked to obtain a photocopy of his medical records regarding the surgical procedure and the physical rehabilitation following the thermal capsulorrhaphy procedure. The subject will then be asked to complete the questionnaire and return it along with the copies of the medical records. Attached are copies of the consent form, and the data collection form with interview questions and chart review information that is to be gathered for analysis and comparison.

After the subject has responded to the questions in writing and has provided photocopies of the requested medical records, the information will be compiled. If deemed necessary, the subject will be contacted for clarification to any answers given. The information collected will be used to write up a case study regarding the outcomes of this surgical procedure and the subsequent rehabilitation. The information provided by the subject will be compiled in chronological fashion. This study will specifically look at the subject's surgical findings, and course of physical therapy treatment after the surgical intervention. The purpose for obtaining this information is to compare this subject's case with published protocols for this procedure and to discuss the clinical outcome data of this subject to assess viability of physical therapy treatment as a result of the surgical intervention for this subject. This study will also allow for the opportunity to examine a long-term clinical outcome for a subject who has undergone thermal capsulorrhaphy to the shoulder, which is not reported in the literature at this time.

3. BENEFITS: (Describe the benefits to the individual or society.)

1. Information gathered will contribute to physical therapy knowledge base regarding treatment and clinical outcomes for patients who have undergone the thermal capsulorrhaphy procedure to their shoulder.
2. This subject's rehabilitation can be compared to other rehabilitation programs that have been tried for this same procedure.
3. This study will provide a patient's perspective on the procedure and the subsequent physical therapy rehabilitation process.
4. This case study will allow for the possibility of long term follow up and an outcome study, which have not been reported in literature at this time.
5. This study will provide the opportunity for the subject to ask questions and learn more about the thermal capsulorrhaphy procedure he had done and the subsequent rehabilitation that he received.

- 4. RISKS:** (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to protect the confidentiality of data obtained, debriefing procedures, storage of data, how long data will be stored (must be a minimum of three years), final disposition of data, etc.)

The physical risks or risks to the subject's dignity and self-respect in this study are minimal. The subject's confidentiality will be protected, as no identifying information will be revealed as part of this study. Any copies of medical records received for review will have all identifying information blacked out and will be stored in a locked cabinet in the UND Department of Physical Therapy. Access to this information will only be myself and my faculty preceptor Sue Jenö. Consent to participate in this study will be obtained by having the subject sign the attached consent form.

- 5. CONSENT FORM:** Attach a copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for how long (must be a minimum of 3 years), including plans for final disposition or destruction.

See attached consent form. After this study is complete, all information gathered about the subject, including the signed consent form, will be stored in a locked office or locked storage room at the UND Physical Therapy Department for three years. After three years have passed since completion of this study all information gathered on this subject will be destroyed with a paper shredder.

6. For **FULL IRB REVIEW** forward a signed original and fifteen (15) copies of this completed form, including fifteen (15) copies of the proposed consent form, questionnaires, examples of interview questions, etc. and any supporting documentation to the address below. An original and 19 copies are required for clinical medical projects. In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 7 copies if the proposal is clinical medical. If the proposed work is being conducted for a pharmaceutical company, 7 copies of the company's protocol must be provided.

Office of Research & Program Development
University of North Dakota
Grand Forks, North Dakota 58202-7134

On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original, including a copy of the consent form, questionnaires, examples of interview questions, etc. and any supporting documentation to one of the addresses above. In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

Principal Investigator

Project Director or Student Adviser

Training or Center Grant Director

Date

Date

Date

(Revised 2/2000)

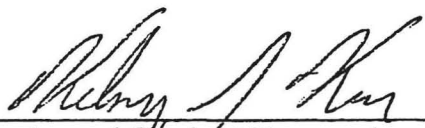
STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your "Human Subjects Review Form."

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD¹

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the Institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit. The study to which this release pertains is Thermal Capsulorrhaphy of the Shoulder: Literature Review and Clinical Outcome
For One Collegiate Tennis Player

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that this policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

11/17/00
Date


Signature of Student Researcher

¹Consent required by 20 U.S.C. 1232g.

Data Collection Form

Interview Questions:

Why did you under go thermal capsulorrhaphy procedure to your shoulder?

Did you receive conservative treatment (physical therapy or other) prior to the thermal capsulorrhaphy procedure?

What were your goals for physical therapy rehabilitation after surgery?

Are you satisfied with the outcome of your surgery and physical therapy rehabilitation?

What do you feel could have been better regarding physical therapy rehabilitation?

How involved was your surgeon regarding your physical therapy rehabilitation?

Do you feel that you are you limited or restricted in any activities today since undergoing the thermal capsulorrhaphy procedure?

Any other comments or concerns regarding the thermal capsulorrhaphy procedure?

Medical Records:

Surgeon's Diagnosis:

Date of surgery:

Surgeon's finding preoperatively:

Surgeon's finding intra and post operatively:

Physical Therapy Initial Evaluation:

Physical Therapy Daily Progress Notes:

Physical Therapy Discharge Summary:

INFORMATION AND CONSENT FORM

TITLE: Thermal Capsulorrhaphy of the Shoulder: Literature Review and Clinical Outcome For One Collegiate Tennis Player

Principal Investigators: Sue Jenö, a physical therapy instructor at the University of North Dakota and Kelsey Kean, a physical therapy student at the University of North Dakota

You are being invited to participate in this study of thermal capsulorrhaphy of the shoulder and the subsequent rehabilitation process. The purpose of this study is three fold. First purpose is to review the literature regarding the most recent development of thermal capsulorrhaphy procedure. The second purpose is to compare and contrast different post surgical rehab protocols that have been attempted with this patient population and determine which rehab protocols are most successful. And the third purpose of this study is to examine the clinical functional outcome for one collegiate tennis athlete. We hope that the results of this study will further the physical therapists knowledge base regarding the rehabilitation process for the patient who has undergone the thermal capsulorrhaphy procedure for the shoulder.

You were chosen because: 1) you underwent the thermal capsulorrhaphy procedure to your shoulder, 2) you received physical therapy to rehabilitate your shoulder, 3) you are an overhead athlete for whom shoulder stability is needed for participation in your sport.

As a subject for this study, you will be asked to fill out an interview questionnaire regarding your shoulder injury and rehabilitation experience following the thermal capsulorrhaphy procedure. You will also be asked to request copies of your postoperative report and physical therapy documentation regarding your rehabilitation from the thermal capsulorrhaphy procedure. A follow up interview may be conducted to clarify answers given in the questionnaire.

The investigators in this study feel that physical risk or risks to your dignity and self-respect are minimal. Your name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department at the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

The investigators involved are available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Sue Jenö at (701) 777-3662. At your request, you will be given a copy of this form for future reference.

In the event that this research activity results in a physical injury, medical treatment will be as available as it is to a member of the general public in similar circumstances. You and your third party payer must provide payment for any such treatment.

All of my questions have been answered and I am encouraged to ask any questions that I may have concerning this study in the future. I have read all of the above and willingly agree to participate in this study as it is explained to me by Kelsey Kean.

Subject's signature

Date

APPENDIX B

October 10, 2000

Julie Lowley, Permissions Editor
W.B. Saunders Company
The Curtis Center
Independence Square West
Philadelphia, PA 19106

RECEIVED
OCT 23 2000
PERMISSIONS

Dear Julie Lowley:

I am a physical therapy student at the University of North Dakota. In partial fulfillment of Master of Physical Therapy degree I am completing an independent study project. I am writing you to request permission to reproduce copies of the three figures listed below from the book "*The Shoulder*" 2nd edition volume 1.

Figure 1-33 page 15
The glenoid labrum
Source: *The Shoulder*: 2nd edition. Rockwood and Matsen

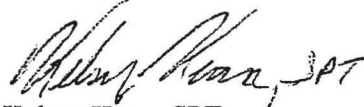
Figure 1-39 page 18
Three common variation of the origin of the superior glenohumeral ligament
Source: *The Shoulder*: 2nd edition. Rockwood and Matsen

Figure 1-58 page 26
Anatomic depiction of the Glenohumeral ligaments.
Source: *The Shoulder*: 2nd edition. Rockwood and Matsen

Three copies will be made for the following uses: Graduate School, Physical Therapy Library, and for my own personal copy of my independent study. The standard credit line will be used to give proper recognition for the figures used.

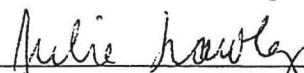
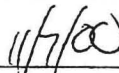
Thank you in advance for your attention to this request and a prompt response is always appreciated.

Sincerely,



Kelsey Kean, SPT
522 Swanson Hall
Grand Forks, ND 58202
kkean@medicine.nodak.edu
Fax # 1-701-777-4199

Approval is given to Kelsey Kean, Physical Therapy student at the University of North Dakota, for copying the above publication for educational purposes as outlined above.


Julie Lowley, Permissions Editor

Date

Permission granted as per phone conversation to Kelsey Kean for the use of figures for the purpose of an independent study project on September 28, 2000 by Elizabeth Anderson, employee of Oratec® Interventions, Inc. 3700 Haven Court, Menlo Park, CA 94025; Phone 888-996-1996, or 650-369-9904

Brochure source:

Temperature Matters. Oratec® Interventions, Inc. [package insert], 3700 Haven Court, Menlo Park, CA 94025; Phone 888-996-1996, or 650-369-9904; www.oratec.com.

Figure 1. Type I Collagen Molecule Model Pre thermal treatment

Figure 2. Type I Collagen Molecule Model Post thermal treatment

November 15, 2000

Permissions Editor

The Journal of Bone and Joint Surgery

20 Pickering Street

Needham, MA 02492

Fax: (781) 449-9787

Dear Permissions Editor:

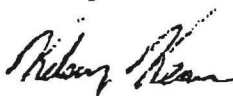
I am a physical therapy student at the University of North Dakota. In partial fulfillment of Master of Physical Therapy degree I am completing an independent study project. I am writing you to request permission to reproduce copies of the figure listed below from *The Journal of Bone and Joint Surgery (American)* volume 74-A, No 6, July 1992. Article title: Treatment of Instability of the Shoulder with an Exercise Program. Authors: W.Z. Burkhead JR. and Charles A. Rockwood JR.

Figure 1-A page 892. A specific rehabilitation program to strengthen the deltoid, rotator cuff, and scapular stabilizer muscles.

Three copies will be made for the following uses: Graduate School, Physical Therapy Library, and for my own personal copy of my independent study. The standard credit line will be used to give proper recognition for the figure used.

Thank you in advance for your attention to this request and a prompt response is always appreciated.

Sincerely,



Kelsey Kean, SPT
522 Swanson Hall
Grand Forks, ND 58202
kkean@medicine.nodak.edu
Fax # 1-701-777-4199

Approval is given to Kelsey Kean, Physical Therapy student at the University of North Dakota, for copying the above publication for educational purposes as outlined above.

Stephen Tilton

Permissions Editor,

22 November 2000

Date



LIPPINCOTT
WILLIAMS & WILKINS

A Wolters Kluwer Company

10/13/00

UNIVERSITY OF NORTH DAKOTA
KELSEY KEAN SPT
522 SWANSON HALL
GRAND FORKS, ND 58202

Invoice # B34821471 Customer # 000110599723
Re: , SPORTS MED & ARTHRO REV
Spec Mat: 1999:7(2);117-127,FG2A,B,3,6,7,8

FEE: 0.00

CONDITIONS OF AGREEMENT

Permission is granted upon the return of this signed agreement to Lippincott Williams & Wilkins (LWW). Please sign and date this form and return with payment (if applicable) in the enclosed envelope. Please retain a copy for your files. This permission is subject to the following conditions:

- 1) A credit line will be prominently placed and include: for books - the author(s), title of book, editor, copyright holder, year of publication; for journals - the author(s), title of article, title of journal, volume number, issue number and inclusive pages.
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- 8) Payment can be made via credit card (Amex, VISA, Discover and MC) or by check.

Card # _____ Exp Date: _____

Requestor accepts: _____

Date: 10/24/00

REFERENCES CITED

REFERENCES CITED

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